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FINAL ENGINEERING REPORT
ON
AUTOMATIC TEST EQUIPMENT STUDY EXTENSION
FOR
DAYTON AIR FORCE DEPOT

CONTRACT NO. AF33 (604) -3[illegible]
FILE NO 100.195

#19.75

GENERAL DYNAMICS | ELECTRONICS

MILITARY PRODUCTS DIVISION—ROCHESTER

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FINAL ENGINEERING REPORT

on

AUTOMATIC TEST EQUIPMENT EXTENSION

for

DAYTON AIR FORCE DEPOT

CONTRACT NO: AF 33(604)-32036

FILE NO: 100.195

GENERAL DYNAMICS/ELECTRONICS
A Division of General Dynamics Corporation
Rochester, New York

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Foreward

This report was prepared by the Electronics Engineering Department of General Dynamics/Electronics, A Division of General Dynamics Corporation, under the sponsorship of Dayton Air Force Depot, Dayton, Ohio, under USAF Contract AF 33-(604)-32036. The study work covered in this report was performed by General Dynamics/Electronics personnel at DAAFD and Rochester under the guidance of MDNE and MDNNOA personnel.

Acknowledgement is made of the assistance provided by Col. J. Riggs, Mr. F. Ruther, Mr. L. Develbiss, Mr. M. Woodruff, Mr. Neil Banke, Mr. R. Stimson, and Mr. J. Eier.

Abstract

~~This document covers~~ work performed on a study program determining the detail requirements for an Automatic Test System for testing of Airborne Electronic Equipment. This program was an outgrowth of a feasibility study ~~previously completed at DAAFD under USAF Contract~~ AF 33(604)-28541.

Presented is ~~This report presents in sufficient detail~~ the technical information required to pursue an equipment development program of the versatile automatic test system utilizing a "building block" concept of design. The system ~~as specified~~ will have ~~the~~ capabilities of performing fault isolation on over 35 airborne electronic systems (not including WRAMA equipments) including piece part fault location on ~~the~~ various subassemblies of these systems. The automatic test system is not limited ~~however~~ to the 35 airborne electronics systems studied in detail, ~~during the study,~~ but has an estimated capability of checking 80% (exclusive of special cables required) of electronic equipment in the Air Force Inventory.

Various problems associated with implementing an automated test facility were considered and studied. ~~during the program.~~ Those considered were logistic support, planning, scheduling and changing skill levels. Also considered ~~in the study~~ were economic advantages gained due to expected increase in MTBF of the airborne electronic equipment due to exhaustive testing possible thru use of automation.

Recommendations

As a result of studies completed under Contracts AF 33(604)-28541 and AF 33(604)-32036, it is recommended that DAAFD implement a trial ATE time shared installation using the building blocks specified. DAAFD has already engaged in ATE hardware programs demonstrating ATE application to checkout of the AN/ARC-27 and AN/APX-6, AN/APX-25. These programs have demonstrated the feasibility of applying ATE to the testing of specific depot inventory items using special purpose adapters for each item.

By implementing a building block ATE installation and applying it to a variety of inventory items, DAAFD can check the validity of the following study program conclusions.

a. Time sharing is a definite means of increasing ATE efficiency. ATE work standards have been estimated based on time shared operation. These estimates should be confirmed.

b. A building block approach to stimulus generator, response monitor, load, and programmer controller design is a sound approach to the problem of eliminating relatively expensive special purpose adapters for each prime equipment tested and the problem of test equipment obsolescence.

c. ATE can be used for defective module and component isolation of the 21 prime equipments studied. Test point accessibility, while somewhat of a problem with current inventory items, will still permit isolation to defective modules and one, two or three components within modules.

d. The 21 prime equipments studied are a valid representation of typical inventory items. The ATE implementation plan should include several newer systems not studied to check this assumption.

e. The building blocks specified in this study will eventually completely replace corresponding manual equipments as automation becomes depot wide. Items which will be replaced are manual signal generators, electronic counters, transfer oscillators, and power supplies. The depot will continue to use manual multimeters, special accessories (absorption type wavemeters, R F. plumbing accessories, etc.) and on a limited basis oscilloscopes and manual spectrum analyzers.

f. Use of ATE in depot operations will result in definite and significant economies in depot operations. While the expense of initial investment in ATE must be written off, the types and quantities of general and special purpose manual test equipment procured in the future will diminish. In the immediate future, savings in man hours per equipment or module tested will be realized. In the near future, additional savings in increased prime equipment reliability will be realized.

In addition to checking the validity of study program conclusions, a trial ATE installation will furnish new information in related ATE areas. These are:

a. Programming and tape preparation simplifications.

b. Simplification and standardization of cables, adapters and fixtures.
c. Recommendations for test points in future prime equipments.
d. Recommendations for TM formats for ATE utilization.
e. Optimum test bench configurations.
f. Optimum operational procedures in time sharing.
g. Finalizing specifications of building blocks.

Programming simplification techniques are recommended in Section 2.4. Additional techniques in simplifying the preparation of tape test programs will become apparent as a variety of programs are made.

The initial ATE implementation will also furnish needed information on test cable and simplified adapter designs. For example, standard cables for connection of low frequency switching to the unit under test may consist of several tube socket adapters and several clip lead terminations for component isolation. Other cables must terminate in tee connections with AN connectors. A standard high frequency cable may terminate in several BNC connectors. Cable standardization requires further consideration since as many as 477 different modules and 79 different black boxes were present in 21 systems.

The ATE implementation will also provide further information on the need for standard test point connectors and accessible test points in newer systems with recommendations for built in detectors, dividers and isolation networks to permit the required degree of fault isolation. Submitted with this report are recommended test data formats for use by prime equipment suppliers. Technical manuals studied to date do not present data in a form easily used by an ATE programmer. Present test procedures are written for the use of manual test equipment. High and low measured value limit information is incomplete. Operation of a trial ATE installation will suggest changes in documentation requirements on prime contractors. Future TM test procedures will probably be written using simple ATE routines.

A simple, portable test bench is recommended in this study. This test bench supports the unit under test, its fixture and accessories such as special high power R.F. dummy loads. A trial installation will determine optimum dimensions for this bench and suggest other possible functions such as cable storage.

At this time operational procedures for a time shared ATE system are not completely defined. Actual system operation is needed to determine the most effective work flow patterns, effects of operator participation in tests and practices needed to reduce interference of operating personnel with each other. The recommended ATE system as described in the final report under Contract AF 33(604)-28541 performs both static (resistance, D.C. voltage, continuity) and dynamic module tests at the same test bench using the time shared ATE. If static tests were conducted at a separate bench with a voltage resistance tester, the manual operation of module connection to the test setup is duplicated. ATE operation is needed to confirm this recommendation.

Finally, the building block specifications presented in this report must be finalized by actual use of the building blocks as described. Requirements not apparent from study alone will manifest themselves once the ATE is operational.

It is recommended that DAAFD implement a trial ATE system consisting of a programmer controller with control computer tie in capabilities and at least thirty of

the forty-two types of building blocks specified. This will provide capability for time shared operation of at least two test benches.

Figure 1 is a tabulation of building blocks in order of usage in black box and module testing. The building block usage for black box testing (% of black boxes requiring this building block for defective module isolation) shows a gradual decrease from 100% to 1.3%. However, for module testing a distinct break occurs in the region from 19% to 7.6% and sixteen building blocks are used by more than 19% of the modules for component isolation tests.

Figure 1 . Building Block Usage in Black Box and Module Testing

Building Block	Percent of Black Boxes Requiring its Usage	Building Block	Percent of Modules Requiring its Usage
P/C	100	P/C	100
Delay Generator	97.5	Delay Generator	99.1
Multimeter	97.5	Multimeter	96.5
P.S. 22-32 V	76	Impedance Meter	67
T.I. & Freq. Meter	67.5	P.S. 30-500 Vdc	61
P.S. 30-500 Vdc	60	P.S. 22 32 Vdc	54
Pulse Generator	56	T.I. & Freq. Meter	39
A.C primary supply	52	A.C. supply 6.3 V	34.4
Waveform analyzer	48	Osc. 0.1 cps - 30 Kc	34
Resistive Load	42	P.S. 0.1 - 35 V	32.5
Oscillator 0.1 cps - 30 Kc	39	Resistive Load	31
Oscillator 30 KC - 40 MC	25.6	Pulse Generator	29.2
Oscillator 40 MC - 400 MC	22.8	Osc. 30 KC - 40 MC	27.6
P.S. 0.1 V - 35 V	22.8	Waveform Analyzer	25.5
Peak power meter	21.5	A.C. primary supply	22.6
Trans. Osc. 5 MC - 175 MC	19	Osc. 2.0 - 4.0 KMC	19
Power meter & Reflectometer	19	A.C. supply 400 cps	7.6
P.S. 500 V - 6 KV	16.5	Osc. 40 - 400 MC	6.1
Osc. 8.5 - 12.4 KMC	15.4	Power meter & Reflectometer	5.1
A.C. supply 400 cps	13.9	Transfer Osc. 5 - 175 MC	4.4
A.C. supply 6.3 V	13.9	10 MC Video amp	4.2
10 MC Video amp	12.7	P.S. 500 V - 6 KV	4.0
Osc. 2.0 - 4.0 KMC	8.9	Capacitive Load	3.4
A.C. supply 400 cps phase ref	8.9	Spectrum Analyzer	2.9
Osc. 950 MC - 1250 MC	7.6	Inductive Load	2.3
AM detector	6.3	100 MC Video amp	2.1
Capacitive Load	5.1	Transfer Osc. 1.475-12.4 KMC	1.5
Impedance Meter	5.1	Noise Generator	1.5
Spectrum Analyzer	5.1	Osc. 950 MC - 1250 MC	1.3
Transfer Osc. 165-605 MC	3.9	Osc. 8.5 KMC - 12.4 KMC	1.3
100 MC Video amp	2.5	Transfer Osc. 165-605 MC	1.3
Noise Generator	2.5	A.C. supply 400 cps phase ref	1.3
Synchro Trans.(Ratio transformer)	2.5	Synchro Trans.(Ratio transformer)	1.0
Inductive Load	2.5	Transfer Osc. 475-1525 MC	.85
Phase Meter	2.5	AM detector	.84
Osc. 12.4-18 KMC	1.3	A.C. supply 30 cps	.84
Spectrum Analyzer 12.4-18 KMC	1.3	Peak Power Meter	.2
Static Press. Gen.	1.3		

Figure 2 is a re-tabulation of building blocks in a recommended priority listing. This listing considers frequency of usage of a building block in both black box and module testing, and also suggests procuring complementary building blocks such as oscillators and transfer oscillators together as the recommended calibration procedures call for checking oscillators using the companion transfer oscillators.

Figure 2 . Recommended Priority Listing of Building Blocks

Priority	Building Block
1	Programmer Controller
2	Delay Generator
3	Multimeter
4	Impedance Meter
5	Time Interval and Frequency Meter
6	Oscillator 0.1 cps - 30 KC
7	Power Supply 22 - 32 Vdc
8	Power Supply 30 - 500 Vdc
9	Pulse Generator
10	Waveform Analyzer
11	A.C. Primary Supply
12	A.C. Supply 6.3 V
13	Resistive Load
14	Power Supply 0.1 - 35 Vdc
15	Oscillator 30 KC - 40 MC
16	Transfer Oscillator 5 MC - 175 MC
17	Oscillator 40 MC - 400 MC
18	Transfer Oscillator 165 - 605 MC
19	Peak Power Meter
20	Power Meter and Reflectometer
21	Oscillator 8.5 - 12.4 KMC
22	Transfer Oscillator 1.475 - 12.4 KMC
23	A.C. Supply 400 cps
24	10 MC Video Amplifier
25	Oscillator 2.0 - 4.0 KMC
26	Power Supply 500 V - 6 KV
27	A.C. Supply 400 cps phase referenced
28	Oscillator 950 MC - 1250 MC
29	Transfer Osc. 475 - 1525 MC
30	Spectrum Analyzer
31	Capacitive Load
32	AM Detector
33	Inductive Load
34	100 MC Video Amplifier
35	Noise Generator
36	Synchro Transmitter (Ratio Transformer)
37	Oscillator 12.4 - 18 KMC
38	Transfer Osc. 12.4 - 18 KMC
39	Spectrum Analyzer 12.4 - 18 KMC
40	Function Generator
41	Phase Meter
42	A.C. Supply 30 cps
43	Static Pressure Generator

Figure 3 is a summary of the ATE capability with all building blocks specified. This lists building block function, frequency range and other key parameters. An ATE implementation of less than 43 types of building blocks will reduce the system capability accordingly.

Figure 3. ATE System Specifications

Function	Frequency Range	Other Parameters	No. of Building Blocks
A.F. and R.F. Generation	0.1 cps - 400 MC		3
	950 MC - 1250 MC	-10 dbm to -100 dbm	1
	2 KMC - 4 KMC	+34 dbm to -100 dbm	1
	8.5 KMC - 18 KMC	+40 dbm to -100 dbm, 8.5 - 12.4 KMC	1
		+10 dbm to -90 dbm, 12.4 - 18 KMC	1
Noise Generation	1 cps - 2 KMC	25 db 1 cps - 10 MC 15 db 10 MC - 2 KMC	1
Synchro, Resolver Excitation	400 cps	Ref. and $\pm 30^\circ$ or $\pm 90^\circ$ or 180° outputs	1
	30 cps	Ref. and $\pm 90^\circ$ and 180° outputs	1
Function Generation	100 - 2500 pps	triangular, sawtooth, trap ezoidal	1
Pulse Generation	.6 cps-3.3 MC PRF	0.1 usec - 1.5 sec pulse width	1
Delay Generation		3 usec - 1.6 sec.	1
Static Pressure Generation		2.5 psia - 14.5 psia	1
Frequency Measurement	99.9 cps-9.99 MC 5 MC - 18 KMC	.999 usec - 999 sec. time	1 counter 5 trans. osc.
Spectrum Analy.	962 MC - 18 KMC		3
Phase Measurement	2 MC - 30 MC		1
Avg. Pwr. Msmt.	2 MC - 12.5 KMC	-20 dbm to +10 dbm	1
Peak Pwr. Msmt.	400 MC - 18 KMC	0 - 300 mw	1
Waveform Measurement	2 pps-83,300 pps PRF	.05 usec - 100 msec rise, fall time, pulse width	1
Impedance Measurement		10 uufd - 1000 ufd 10 uh - 100 h 100 ohms - 5 Meg RC 5 ohms - 1 Meg RL	1

Function	Frequency Range	Other Parameters	No. of Building Blocks
Voltage Measurement	10 cps - 10 KC	.999 V - 500 Vdc .999 V - 500 Vac	1
Resistance Measurement		9.99 ohms - 9.99 megohms	
Video Amp	1 KC - 10 MC	20 db gain	1
	100 KC - 120 MC	20 db gain	1
D.C. Power		.1 - 35 V, 2.5 A	1
		22 V - 32 V, 27 A	1
		30 V - 500 V, 1 A	1
		500 V - 6000 V 800 ma to 1 KV 250 ma to 6 KV	1
A.C. Power	400 cps	16 V - 300 V, 7 A	1
		6.3 V, 10 A	1
	400 cps	95 V - 130 V, 40 A, 1 Ø	1
		104 - 130 V, 15 A, 3 Ø	
Loads		Res. 0.1 ohm - 7 Megohm	1
		Cap. 10 uufd - 10 ufd	1
		Ind 1 mh - 3 h	1
AM Detector	400 cps-30 MC carrier 0 - 20 KC modulation		1
Synchro trans/ Ratio Trans.	50 cps - 2000 cps	Resolution 1 part in 2^{15}	1

A programmer controller as specified in this report rather than a control computer is recommended for the initial ATE implementation. The overall depot ATE system recommended includes both types of controllers. It is believed that programmer controllers will continue to be used for conducting large numbers of relatively simple test and control functions even when computer techniques for fault isolation are developed and depot inventory equipment complexity increases.

A control computer, if used initially in place of a programmer controller, can certainly perform its test and control functions. However, the control computer capability for functions other than test sequence control would in all probability be little used for 2 or 3 years as the major work areas of performing tests, test program preparation and variation, proving building block performance and ATE system application to a variety of inventory items will initially tie up the control computer with performing tasks that can be more economically and simply performed by the specified programmed controller.

1. INTRODUCTION

1.1 General

This is the final engineering report on USAF Contract AF 33(604)-32036, an extension of the Automatic Test Equipment Study performed on USAF contract AF 33(604)-28541, completed February 1961. The requirements of a depot oriented test system were defined as a result of the previous study. These requirements were confirmed during the study extension by determining the extent to which the system is adaptable to a changing and different work load. The additional building block requirements found by studying 20 additional systems at Dayton as part of the program were minor when compared with the total requirement. The degree of applicability of the automatic test system as defined for the DAAFD facility requirements for use by other AMA's was investigated. Study teams were assigned to cover selected systems prime for WRAMA, MOAMA, and SAAMA. The results of these efforts confirm the versatility of the building block approach to an automated test system. The information obtained by July 15, 1961 on the studies at the other AMA's is included in this report. The results of the studies not completed by July 15, 1961 will be presented in an addendum to this report.

Other problems associated with the conversion of a repair facility to automation have been studied and defined as a part of the study and are presented herein. The requirements of an automatic test tape program conversion unit for a limited number of programmer controllers types has been investigated and the results are presented herein. Specifications for the recommended and required automatic test system were generated and they are included in the Appendix to this report.

1.2 Objectives

The purpose of the study extension to the study done under USAF contract AF 33(604)-28541 was to confirm the requirements of the automatic test system previously defined. In accomplishing this task, the following additional systems were studied in addition to the original 15.

1. AN/APX-26
2. AN/APX-27
3. AN/ARC-74
4. AN/ARC-57
5. AN/APN-135
6. AN/ARN-50
7. AN/APN-136
8. AN/ALR-12
9. AN/ALQ-16
10. Chaff Dispenser
11. AN/ARR-61
12. AN/ARC-70
13. AN/ARN-62
14. AN/ARN-61
15. AN/APX-37
16. AN/AIC-20
17. AN/ARA-48
18. AN/APX-34
19. AN/APX-46
20. AN/APX-47
21. AN/APX-48

1.2 (contd)

Also included in the study were selected listed units of the AN/ASB-4, A3A, Type K-4A prime at WRAMA, the KL-7, KG-3, KW-26, KL-47, KO-6, and the KY-1 at NSA, San Antonio and selected units of the B-58 automatic test system GSEL 2401, 2403, 2404, 2406 and 2409 prime at MOAMA.

The studies of the additional systems confirmed the building block approach advocated by the previous effort at DAAFD.

A few additional building block requirements were found as was expected. This is obvious if one considers that a certain number of new building blocks will be required until all of the r.f. frequency bands are covered. In addition special accessory items will be required for a portion of any new group of systems that are added to the list of systems to be tested. Looking at the overall picture, however, shows these as a minor requirement as compared to the requirements dictated by the conventional manual repair method or the special purpose automatic test adapter method previously used by many maintenance agencies.

The objectives of the study extension were many fold. The prime objective was to confirm the automatic test system requirements as defined previously, expand upon them and produce a set of specifications to which an initial system could be procured by the Dayton Air Force Depot. This has been accomplished and a general specification as well as 46 individual electrical characterisitc specification sheets for the building blocks has been completed thru joint efforts of MDNE and GD/E. The individual specification sheets are included in the appendix of this report.

Secondary objectives of the program were to investigate the feasibility of a Code Converter capable of translating one P/C machine language into another, to expand upon the economic advantages of ATE due to effect of increased MTBF obtained when using automatic fault isolation in the repair of equipment, to investigate the requirements for a programmer computer and to study possible methods of automatic test tape preparation. These efforts have been completed and the results are located under their appropriate sections of this report.

Additional objectives of the study were the development of a logical plan to convert DAAFD to ATE and to enumerate in some detail other problems that may arise in converting a repair facility to an automatic testing operation. These have been accomplished. The results are included under the appropriate section of the report.

1.3 Scope

The scope of the study included detailed studies of equipment presently included in the DAAFD inventory and equipment planned for future inclusion in their repair inventory. Detailed studies were also performed on equipment prime at WRAMA,

1.3 (contd)

NSA-SAAMA and MCAMA. Trips were made to the other repair facilities to observe first hand maintenance problems present at these areas.

2. STUDY RESULTS

2.1 Automatic Test System Requirements

2.1.1 Summary

A recommended General Purpose Automatic Test System (GPATS) is defined in this section. Data and results generated during the first study effort, Automatic Test Equipment for DAAFD, Contract No. AF33(604)-28541 have been expended and combined with information obtained from the second, Automatic Test Equipment Study Extension for DAAFD, Contract No. AF33(604)-32036 to define the General Purpose Automatic Test System.

A generalized GPATS block diagram and typical configuration are presented and discussed. Building blocks which comprise the system are referenced by function only in this section. The reader is referred to Appendix 2.46 for performance specifications of the individual building blocks and to other sections of this report for more detailed explanations and discussions than presented in this section of the peripheral equipment and functions this peripheral equipment performs. All performance specifications contain the necessary functions for integration and combination with other building blocks to fulfill the requirements of a General Purpose Automatic Test System.

Study results for a depot oriented Programmer Controller to direct a General Purpose Automatic Test System and operate in conjunction with the peripheral equipment are finalized. The AN/GJQ-9 was investigated to determine the extent to which it would fulfill the defined requirements, and modifications to increase its capabilities are suggested. Serious limitations of a GPATS directed by an AN/GJQ-9, or a modified AN/GJQ-9 are presented.

All functional parallel buss lines which the recommended method for programming requires are defined. Any or all of the building blocks assembled for use at one time may be programmed. This method requires the minimum amount of operator decisions and labor to modify the types, or quantities of assembled building blocks as well as allowing for future growth capabilities for building blocks defined and developed in future years.

Fail safe requirements and maintenance philosophies necessary to determine that malfunctions are present and to minimize malfunction down time of any elements of a General Purpose Automatic Test System are discussed.

2.1.1 (contd)

Several levels of testing and fault isolation are defined, and methods and procedures for performance of these maintenance tests are described.

2.1.2 GPATS Block Diagram and Configuration

Figure 4 and 5 represent a generalized GPATS block diagram and typical configuration of GPATS. The building blocks comprising the set-up of Figure 4 are not representative of building blocks assembled for servicing any particular end item. Rather they depict a universal approach to the assembling of building blocks and demonstrate the flexibility of the system and the ease of adding additional building blocks as they are required or eliminating building blocks no longer required. The quantity of racks supporting the required building blocks is also a function of the end items being serviced. Building blocks which require more space and weight than is practical for rack mounting will be packaged as separate portable units.

Time sharing of both a Programmer Controller and building blocks with each unit under test (UUT) permits GPATS usage at one bench while connections, or disconnections, are performed at the other bench. Unusual signal characteristics or tolerances may limit time sharing of some building blocks for some applications.

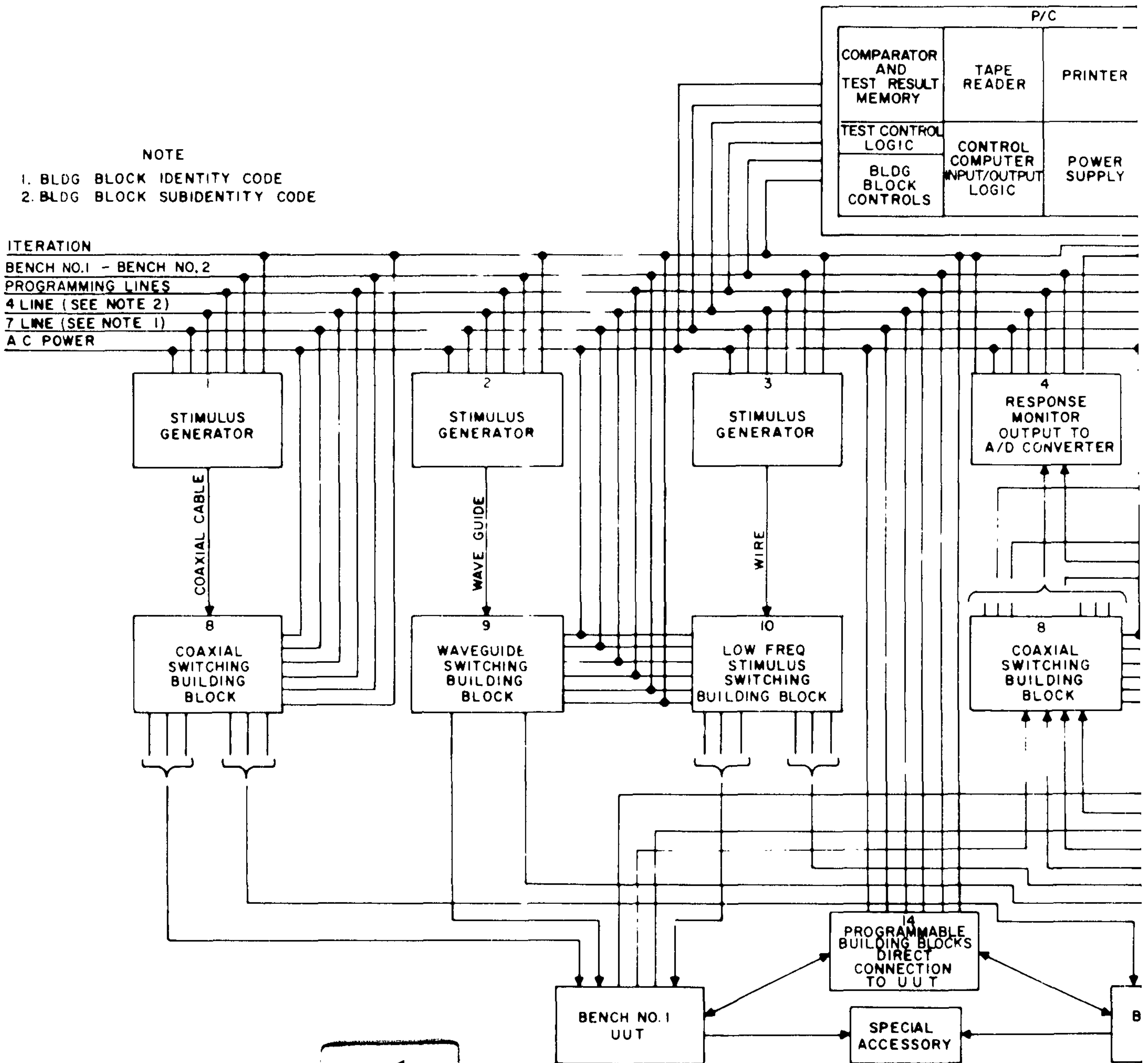
Similarly, a Control Computer with Data Processing capability is available for the use of several Programmer Controllers on a time shared basis. See Section 2.3.

2.1.3 Programmable Building Blocks

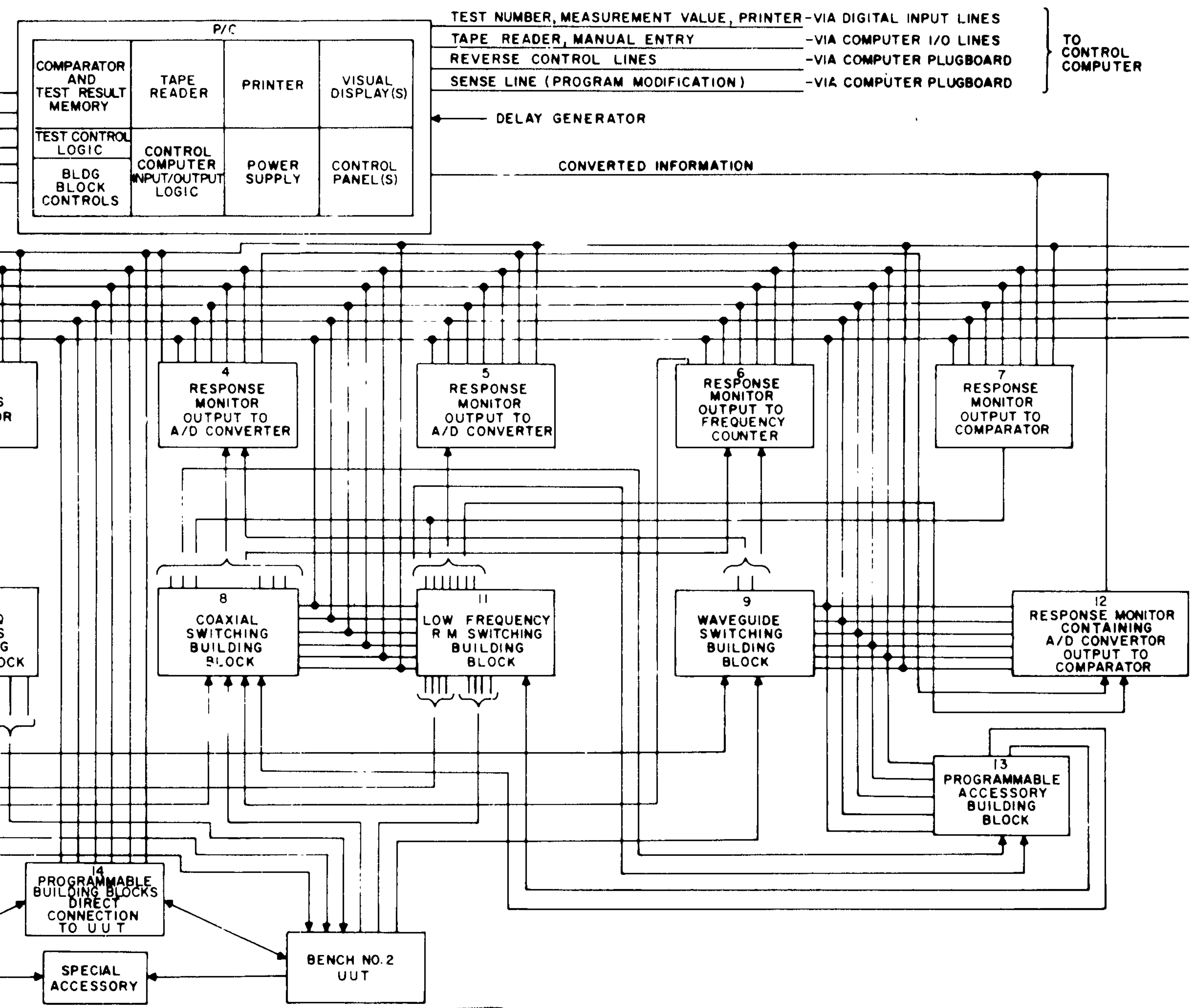
Programmable stimulus generators, response monitors, switching units and accessories are classified as building blocks. Requirements and characteristics of the building blocks are as finalized during this study program. Figure 6 lists all building blocks considered, the category in which they are placed, and also the reference number of Figure 6 to correlate a particular building block and its location in the block diagram of Figure 4. The location is for the typical case, and may be varied for different testing applications or signal characteristics. See Sections 2.1.8 and 2.1.9 for input lines to the building blocks.

2.1.4 Programmer Controller

2.1.4.1 Summary: Study results of a depot oriented Programmer-Controller for GPATS and the peripheral equipment of Section 2.1.6 are finalized in this section. The final results define a Programmer-Controller capable of integration with the GPATS system concept and the peripheral equipment to perform its results. Programmable stimulus generators, response monitors, accessories and switching units are not an integral part of the recommended Programmer Controller, although it performs functions for the building blocks similar to those performed by operational Programmer Controllers.


P/C
COMPARATOR AND TEST RESULT MEMORY
TAPE READER
PRINTER
TEST CONTROL LOGIC
CONTROL COMPUTER INPUT/OUTPUT LOGIC
POWER SUPPLY
BLDG BLOCK CONTROLS
NOTE
1. BLDG BLOCK IDENTITY CODE
2. BLDG BLOCK SUBIDENTITY CODE
ITERATION
BENCH NO.1 - BENCH NO.2
PROGRAMMING LINES
4 LINE (SEE NOTE 2)
7 LINE (SEE NOTE 1)
A C POWER
1
STIMULUS GENERATOR
2
STIMULUS GENERATOR
3
STIMULUS GENERATOR
4
RESPONSE MONITOR OUTPUT TO A/D CONVERTER
COAXIAL CABLE
WAVE GUIDE
WIRE
8
COAXIAL SWITCHING BUILDING BLOCK
9
WAVEGUIDE SWITCHING BUILDING BLOCK
10
LOW FREQ STIMULUS SWITCHING BUILDING BLOCK
8
COAXIAL SWITCHING BUILDING BLOCK
14
PROGRAMMABLE BUILDING BLOCKS DIRECT CONNECTION TO UUT
BENCH NO.1 UUT
SPECIAL ACCESSORY
B

1



2

Figure 4. Generalized GPATS Block Diagram

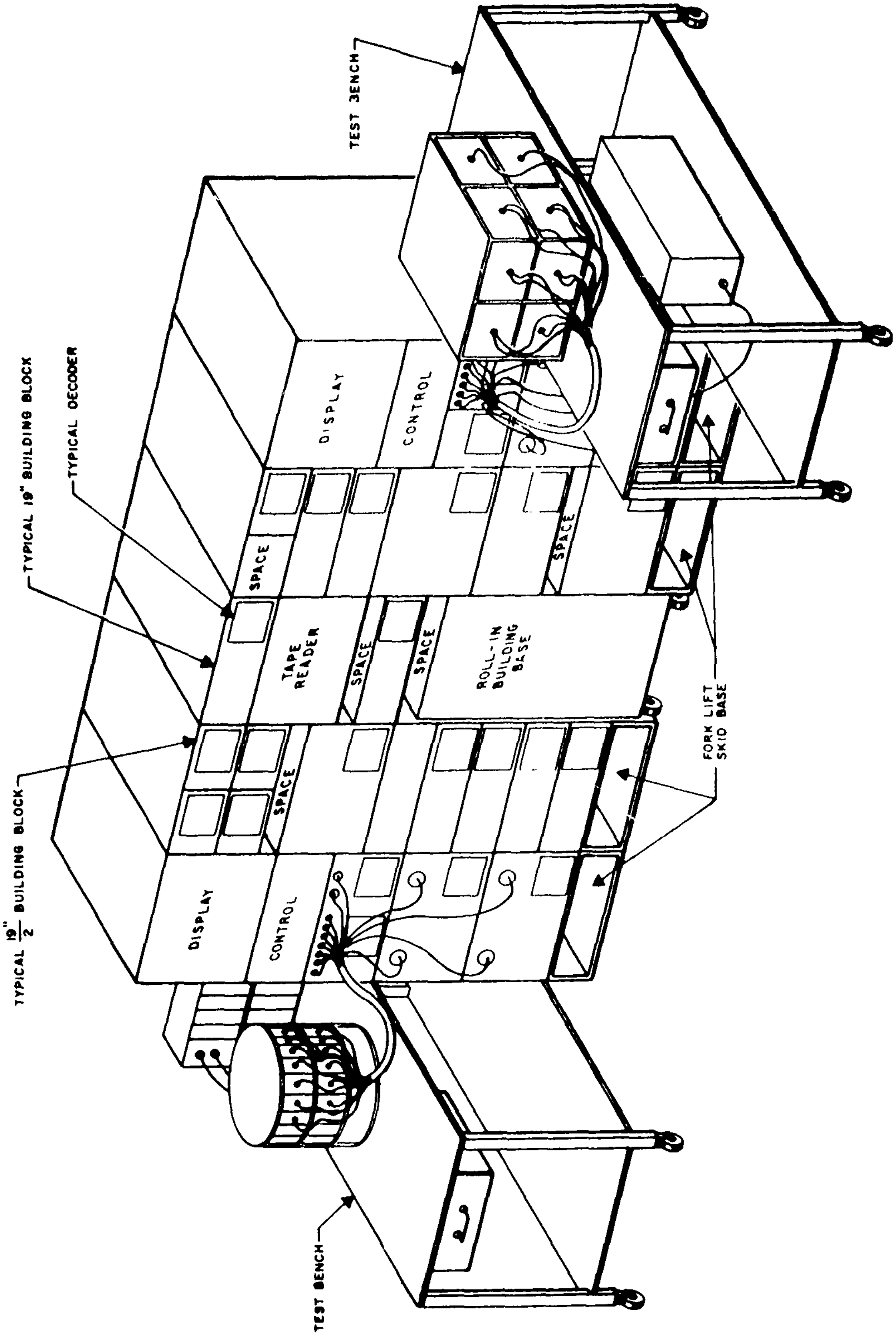


Figure 5. Typical Configuration of GPATS

Building Block Data

Figure 6

P.S.G. = Programmable Stimulus Generator
P.R.M. = Programmable Response Monitor
P.S.U. = Programmable Switching Unit
P.A. = Programmable Accessory

Bldg. Block Number	Item	Category	Reference Figure
1	Oscillator 0.1 cps - 30 KC	P.S.G.	3
2	Oscillator 30 KC - 40 MC	P.S.G.	1
3	Oscillator 40 MC - 400 MC	P.S.G.	1
4	Oscillator 950 MC - 1250 MC	P.S.G.	1
5	Oscillator 8.5 KMC - 12.4 KMC	P.S.G.	2
6	100 MC Video Amplifier	P.A.	13
7	Pulse Generator	P.S.G.	1
8	Delay Generator	P.A.	
9	10 MC Video Amplifier	P.A.	13
10	Transfer Osc. 5 MC - 175 MC	P.R.M.	6
11	Transfer Osc. 165-605 MC	P.R.M.	6
12	Transfer Osc. 475 - 1525 MC	P.R.M.	6
13	Transfer Osc. 1.475 - 10.5 KMC	P.R.M.	6
14	Noise Generator	P.S.G.	1
15			
16	Oscillator 2.0 - 4.0 KMC	P.S.G.	2
17	Oscillator 12.4 - 18 KMC	P.S.G.	2
18	Synchro Transmitter (Ratio Transformer)	P.S.G.	3
19	Resistive Load	P.A.	13
20	Inductive Load	P.A.	13
21	Capacitive Load	P.A.	13
22	Impedance Meter	P.R.M.	5
23	Multimeter	P.R.M.	12
24	Time Interval and Frequency Meter	P.R.M.	7
25	Power Meter and Reflectometer	P.R.M.	4
26			
27	Waveform Analyzer	P.R.M.	4
28	Spectrum Analyzer L band	P.R.M.	4
	Spectrum Analyzer 1.2 - 12.4 KMC	P.R.M.	4
29	Peak Power Meter	P.R.M.	4
30	Static Pressure Generator	P.S.G.	14
31	Spectrum Analyzer 12.4 - 18.0 KMC	P.R.M.	4
32			
33	Phase Meter	P.R.M.	4
34	Amp. Modulator Detector	P.R.M.	4
35	Power Supply 0.1 - 35 VDC (2.5A)	P.S.G.	3

Figure 6 (contd)

Bldg. Block Number	Item	Category	Reference Figure
36	Power Supply 22 - 32 VDC	P.S.G.	14
37	Power Supply 30 - 500 VDC	P.S.G.	3
38	Power Supply 500 - 6000 VDC	P.S.G.	14
39	AC Supply 400 CPS Phase Ref.	P.S.G.	3
40	A.C. Supply 400 CPS 1 ∅	P.S.G.	3
	3 ∅	P.S.G.	3
41	A.C. 6.3 V	P.S.G.	3
42	A.C. Supply 30 CPS	P.S.G.	3
43	A.C. Primary Voltage	P.S.G.	
44	Transfer Oscillator 12-18 KMC	P.R.M.	6
45	Function Generator	P.S.G.	3
46	Coaxial Switching Unit	P.S.U.	8
47	Low Frequency S.G. Switching Unit	P.S.U.	10
48	Low Frequency R.M. Switching Unit	P.S.U.	11
49	Waveguide Switching Unit	P.S.U.	9

2.1.4.1 (continued)

A Programmer-Controller represents a smaller expenditure than other accumulative GPATS equipment such as building blocks, cables and adapters, the peripheral equipment, or tapes containing test programs. However, its function as part of a General Purpose Automatic Test System is of prime importance. It will be a determining factor in the final performance of the test system, not only in the servicing capability and GPATS end item capacity, but also in the ease or effort for operators to perform this servicing. Also, the P/C as defined has several modes of operation to give a skilled operator the flexibility of operation required for initial test tape preparation and debugging. If Programmer-Controller capabilities are limited, performance of the overall test system and the peripheral equipment supporting the test system will be sacrificed.

A block diagram of the proposed Programmer-Controller is shown in Figure 7 and specifications are presented in Appendix 46.

Several comparisons were performed. Specifications for the Programming Set, Check-out Sequence, AN/GJQ-9, MIL-P-26664A were analyzed to determine its capabilities as an integral part of a General Purpose Automatic Test System and its peripheral equipment.

Additional requirements not present in the AN/GJQ-9 are discussed. They are test result memory, information lines for tie in with the Control Computer with Data Processing Capabilities, iteration, and packaging by a functional building block concept.

Modifications for increasing the capability of the AN/GJQ-9 are discussed.

2.1.4.2 Recommended Programmer-Controller Block Diagram

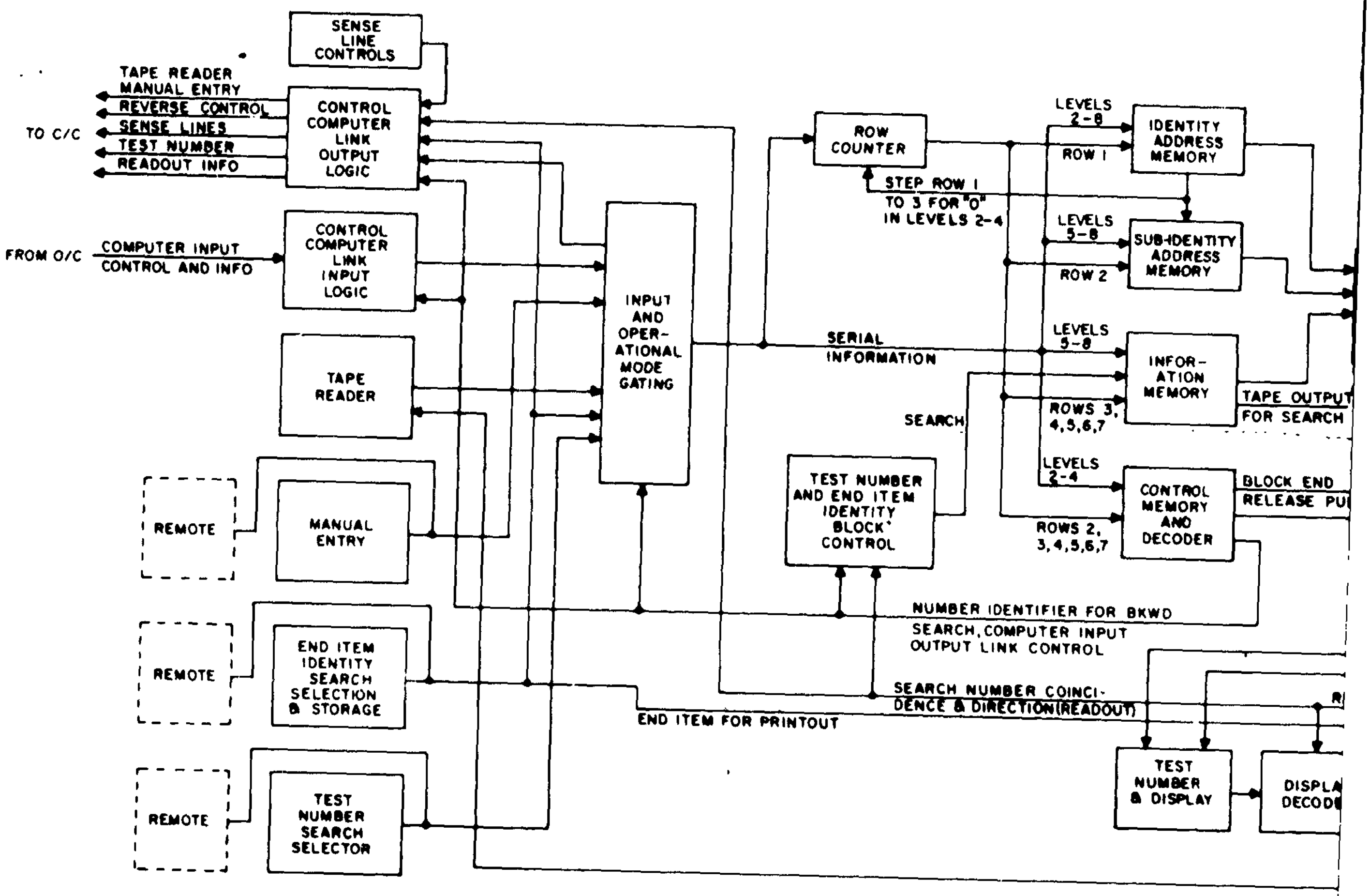
A functional block diagram of a depot oriented Programmer-Controller is shown in Figure 7.

Two functional groups of input/output lines are shown. These are the information input/output lines to join the Programmer-Controller with the Control Computer having Data Processing Capability and with the external building blocks which are being utilized to service the end items.

Placement of several functional capabilities at each of the test benches is recommended in this report. These functions are identified in the block diagram by a duplicate presentation of these functions.

2.1.4.3 Recommended Programmer-Controller and AN/GJQ-9 Comparison

Functional requirements for a machine capable of directing a depot oriented General Purpose Automatic Test System have been developed. Figure 8 presents function requirements, reasons for these requirements, and the capability the AN/GJQ-9 and the recommended Programmer-Controller contain to perform these requirements.


SENSE LINE CONTROLS
TAPE READER
MANUAL ENTRY
REVERSE CONTROL
SENSE LINES
TEST NUMBER
READOUT INFO
TO C/C
CONTROL COMPUTER LINK OUTPUT LOGIC
FROM O/C
COMPUTER INPUT CONTROL AND INFO
CONTROL COMPUTER LINK INPUT LOGIC
TAPE READER
REMOTE
MANUAL ENTRY
REMOTE
END ITEM IDENTITY SEARCH SELECTION & STORAGE
REMOTE
TEST NUMBER SEARCH SELECTOR
INPUT AND OPER-ATIONAL MODE GATING
ROW COUNTER
STEP ROW 1 TO 3 FOR "0" IN LEVELS 2-4
SERIAL INFORMATION
SEARCH
TEST NUMBER AND END ITEM IDENTITY BLOCK' CONTROL
LEVELS 2-8
ROW 1
IDENTITY ADDRESS MEMORY
LEVELS 5-8
ROW 2
SUB-IDENTITY ADDRESS MEMORY
LEVELS 5-8
ROWS 3, 4,5,6,7
INFOR-ATION MEMORY
TAPE OUTPUT FOR SEARCH
LEVELS 2-4
ROWS 2, 3,4,5,6,7
CONTROL MEMORY AND DECODER
BLOCK END RELEASE PU
NUMBER IDENTIFIER FOR BKWD SEARCH, COMPUTER INPUT OUTPUT LINK CONTROL
SEARCH NUMBER COINCI-DENCE & DIRECTION (READOUT)
END ITEM FOR PRINTOUT
TEST NUMBER & DISPLAY
DISPLA DECOD

Figur

1

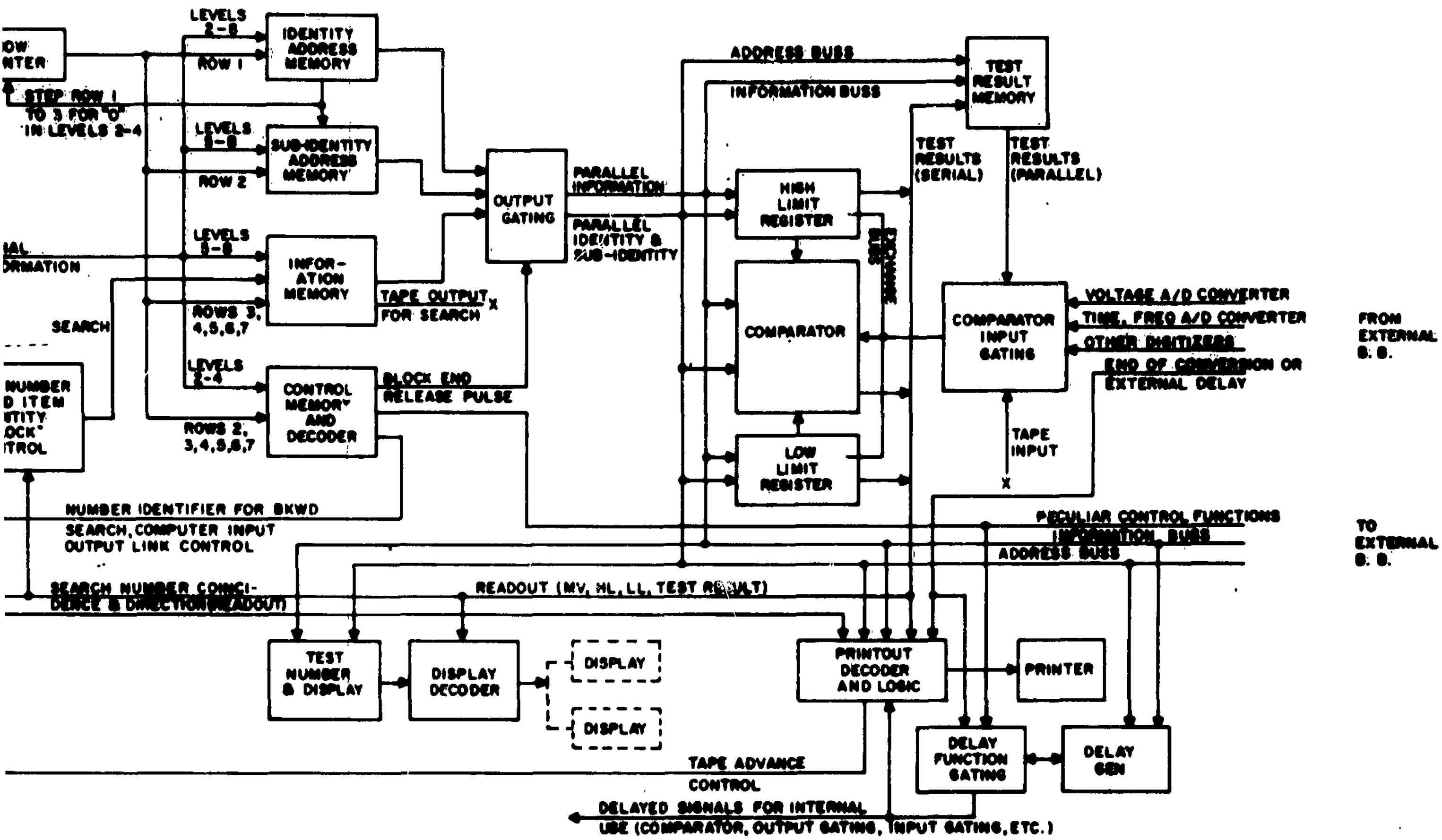


Figure 7. Recommended Programmer-Controller Block Diagram

2

Figure 8

Recommended Programmer-Controller and AN/GJQ-9 Comparison

I Requirements: End Item Identity Information

A. Control Computer (C/C) Operation

1. When the C/C replaces the P/C to direct tests, the C/C will control building blocks required to perform these tests. To gain knowledge of the tests it is required to perform the C/C must receive end item identity and test number information so its memory can be searched to determine the starting point.

2. C/C printout and punched card output of logistics data are required. End item identity and test number information are required for access of memorized (stored) information in C/C.

B. Permanent test record printout by Programmer-Controller is required.

Initial data, representing an end item, will associate the following test data with that particular end item so the test record printout is identified.

Operators Console AN/GJQ-9	Depot Oriented Programmer-Controller
A combination of the particular test tape being utilized at that time and test numbers of that tape are needed to identify end item. Automatic insertion of test tape identity information is not available.	Federal Stock-Class number identifying particular end item (Black Box/Module) is inserted on test tapes. This handles end items having modifications as they have unique FSC numbers assigned. Test number information will remain the same.

II Requirements: Test Search

A. Manual Search: Information entered manually via control panel to command search to end item identity number and particular test number of a test sequence or program.

B. Automatic Search: Search for particular test number of a test sequence or program on command of information on test tape.

Figure 8
II (contd)

Operators Console AN/GJQ-9	Depot Oriented Programmer-Controller
Search for Test Numbers 1 - 99,999 that can be entered manually or programmed on tape. Will not search to end item identity unless they are assigned a particular test number.	Two search modes will be used. One to search to end item identity number (manually inserted) and one to search to particular test number of that end item program (manually inserted or programmed on tape).

III Requirements: Significant Digits of Test Value

Measurements where increased digit capability is required to guarantee that test accuracy is met.

Operator Console AN/GJQ-9	Depot Oriented Programmer-Controller
Three digit comparator, printer, display, tape reader logic, etc. limits accuracy.	Seven digit comparator, printer, display, tape reader and logic capability is provided. Comparison may be accomplished by a simultaneous seven digit comparator capability or by a two step comparison of 4 most significant digits and then the 3 least significant digits. Printout is a two step process if the latter comparison method is used. Storage of 7 digits for display to facilitate operator decisions is required.

IV Requirements: Manual Control Panel

A. Control panels readily accessible to each bench that are capable of controlling the Programmer-Controller are required.

B. Controls for information signals to C/C.

Figure 8
IV (contd)

Operators Console AN/GJQ-9	Depot Oriented Programmer-Controller
Single Control Panel at Programmer-Controller is inadequate for integration with Control Computer and for time sharing P-C and building blocks. No remote control panel capabilities are provided.	Identical control panels with increased control capability allowing C/C integration and time sharing of P/C and building blocks are required.

V Requirements: Visual Display Unit

A. Display units readily visible from each test bench.

B. Fail safe, fault isolation indicators required for building blocks and display for Computer Control mode is necessary.

Operators Console AN/GJQ-9	Depot Oriented Programmer-Controller
Display unit at Programmer-Controller is inadequate for showing integration with C/C and time sharing of P/C and building blocks. No remote capability is provided.	Local and remote visual display units with increased information display capabilities are required.

VI Requirements: D.C. Power Supplies

D.C. power for Programmer-Controller

Operator Console AN/GJQ-9	Depot Oriented Programmer-Controller
Special purpose supplies are used.	Utilization of building block D.C. supplies as defined in A.F. 33-(604)-28541 to replace special purpose supplies should be considered when voltage and current requirements of P/C are determined.

VII Requirements: Autocheck (Self Check)

Monitor of critical functions by fail safe methods.

Figure 8
VII (contd)

Operators Console AN/GJQ-9	Depot Oriented Programmer-Controller
Insufficient information available.	Self check capabilities for critical functions using monitor and fail safe checks. Self test programs for all functions using fault isolation capabilities built into the machine.

VIII Function Requirement: Stimulus generator, response monitor, programmable accessory and switching units (building blocks) selection and programming by coded signals on parallel bus lines.

Measurement and Selector Rack AN/GJQ-9	Depot Oriented Programmer-Controller
Test point selector, selector logic unit, stimuli control unit, and stimuli control logic unit accomplish the programming. It is difficult to program bus lines for external building block control by using existing circuitry and methods.	Building block control circuitry to allow selection and programming of building blocks by either a Programmer Controller or a Control Computer.

IX Function Requirements: Response Monitors - Voltage and Time, Frequency A/D Converters with characteristics compatible with depot service requirements.

Measurement and Selector Rack AN/GJQ-9	Depot Oriented Programmer-Controller
Range, reference, and converter selection, voltage A/D converter and time, frequency A/D converter have inadequate electrical, mechanical and programming characteristics.	Response monitors are an integral part of applicable building blocks which are external to the Programmer Controller.

X Function Requirements: Computer Control Tie in.

AN/GJQ-9	Depot Oriented Programmer-Controller
Some data can be put on test tape and transmitted to Control Computer via external accessory control. No provision for control of building blocks by Control Computer.	Ability to transmit all required information to Control Computer and to receive instructions required to operate the automatic test system. All required controls and indicators are part of the Programmer-Controller.

Figure 8 (contd)

XI Function Requirements: Test Result Memory (See Section 2.13 Appendix 46)

AN/GJQ-9	Depot Oriented Programmer-Controller
Capability does not exist.	Storage of 34 test results for a series of tests (test sequence) to allow test result pattern to be compared to pre-determined failure patterns. Test result memory output is available to comparator, and patterns are inserted in the same manner as limits into the comparator.

XII Function Requirements: Iteration (See Section 2.11 Appendix 46)

AN/GJQ-9	Depot Oriented Programmer-Controller
Capability does not exist.	Programmer-Controller is capable of automatically advancing a desired number of nearly identical tests without reading through a section of tape especially prepared for each test. It is capable of advancing the test number and causing stepping of building block functions (i.e., test point switching, D.C. voltage, stimulus generator frequency).

XIII Function Requirements: Programmer Controller based on building block concept. (See Section 1 Appendix 46)

AN/GJQ-9	Depot Oriented Programmer-Controller
Drawer and bay type construction. In general each unit performs only a specific function.	Programmer-Controller comprised of self contained modules or blocks. Each block performs a specific function in its entirity. Allows substitution for repair purposes of a small section of the Programmer-Controller.

2.1.4.4 Additional Requirement Recommendations

The Programmer-Controller (P-C) recommended for this depot facility is a unit with four features not presently included on any existing machine of this type. The AN/GJQ-9 unit will serve as a basis of reference to discuss features recommended for inclusion in a new P-C.

A Test Result memory is recommended. This memory would store the results of some 34 tests. Its use would reduce the number of subroutines on diagnostic analysis testing. Rather than rushing into a subroutine on a NO-GO, there are many occasions when a pattern of NO-GO's would in itself be sufficient to point out the location of the fault, or the pattern would quickly send the machine to only one appropriate subroutine to further define the fault. The outputs of these memory elements will be available to the comparator for logical comparisons with pre-determined patterns in the form of limits.

The presence of a Control Computer with Data Processing capabilities in the facility has been recommended. If this recommendations is followed, it is further recommended that the Control Computer be electrically connected to the P-C. Details of this connection will be brought out in the following material. Likewise, this feature is not on the AN/GJQ-9.

Another feature strongly recommended for the P-C to be used in the depot maintenance facility is iteration. Every P-C in existance at the present time lacks this feature. The iteration feature will cut programming time and costs greatly, as well as cutting down on the footage of tape required for a complete test sequence. Iterative tests are those whose instructions are essentially repeated from test to test. Perhaps one or two items change one digit, such as the test point switch number, the test numbers, or some stimulus generator parameter. The iteration feature would allow the use of the same instruction sequence on the tape for one test, and appropriate test number, switching or other internal advances made automatically for each iteration. Actually, the feature will allow iteration of any number of tests in a sequence. For example, it may be that a sequence of tests essentially repeats itself every 12 tests. Rather than the first 12 tests being programmed, and followed by the second 12, etc. only one sequence of 12 would be required. After the first pass through the 12 tests, an iteration instruction would be read from the tape. This would set up the selected building blocks to advance automatically. The tape would search to the beginning of the sequence and begin the second pass through. On the second and succeeding passes, the addresses on tape for programming selected building blocks would not direct the block to read the programming lines, but only serve as an advance pulse. This would continue until the iteration counter went to zero. This would release the iteration and return all selected blocks to normal.

Serious consideration of a building block approach to a Programmer-Controller is recommended. Each building block of this Programmer-Controller would be an individual rack mounted package containing hardware to perform a specified function. Reasons for this recommendation are presented below:

2.1.4.4 (contd)

a. Defective Programmer-Controllers present a unique maintenance problem as the amount of fault isolation automatically performed on itself by tape test programs is limited by the malfunction. Inability to operate the GPATS probably indicates it cannot perform all tests necessary to fault isolate its own malfunction to a piece part. This, of course, if dependent upon the functional area of the Programmer-Controller which is defective. Thus performance of Programmer-Controller confidence tests, module isolation tests and piece part isolation tests as defined under GPATS Maintenance Philosophy, which require an operating Programmer-Controller, are not always possible.

Several semi-automatic or manual fail safe or fault isolation indicators and techniques can be applied to greatly ease the fault isolation problem. Isolation to a functional area can be satisfactorily accomplished in this manner. If this functional area is packaged as a separate unit, the maintenance process of substitution of an identical, operating unit is applicable. After this substitution the Programmer-Controller confidence tests can be performed to guarantee that the malfunction is no longer present.

At this point contractor supplied instructions, cables, adapters and test programs and GPATS can then be applied to repair the defective Programmer-Controller building block.

b. Present day hardware used in a Programmer-Controller will be improved in the future as modifications, or new state-of-the-art techniques are developed by manufacturers. If these improvements increase the capability or reliability of the unit sufficiently to warrent their use, it would be easier to substitute the up-dated or new hardware if a building block packaging concept is adopted. Compatibility and interchangeability conditions would then be primarily electrical, instead of both electrical and mechanical.

c. All Programmer-Controller functions required D.C. power. If the building block concept is adopted, after D.C. power, current and voltage characteristics are defined, or estimated, it must be determined whether these voltages are to be generated in and for the use of particular Programmer-Controller building blocks or whether they are to be obtained from external supply sources. Use of the D.C. power supplies of Appendix 34 should be considered for external supply sources for system standardization and reduced logistics support cost. Retaining the power supply programming capability would allow a means of marginal checking the P/C building blocks.

d. Recommendations have been made for placement of some functional units normally associated with a Programmer-Controller at each test bench so GPATS operators may more efficiently perform their function. Control panels and visual display units are examples of units each operator requires. As this remote condition exists, it is practical to design and develop one unit which can meet this dual, or remote location condition.

2.1.4.4 (contd)

e. All Programmer-Controllers require several time base, or time delay generators. Some of these are fixed, wide tolerance delays required everytime a function is performed and others are accurate fixed or variable time delays. The building block time delay generator of Appendix 9 can suffice to generate accurate fixed and variable time information for the Programmer-Controller, as well as for other building blocks, thus eliminating a need for an accurate time base generator designed for and associated with a Programmer-Controller.

2.1.4.5 Modifications of AN/GJQ-9

Possible modifications of the AN/GJQ-9 specifications were considered. As could be expected, the amount of additional capability obtainable is related to the quantity of modifications defined. At this time it is impossible to determine how far to carry a modification program as adequate electrical, time and cost information is not available. The degree of modification was arbitrarily set after analysis of MIL-P-26664A. The criteria for modification was to obtain added capabilities for functions by adding external equipment so that as few internal modifications as possible are required. To make the AN/GJQ-9 more compatible with the automatic test system, some additions or internal modifications listed below, may be made to the AN/GJQ-9.

1. Function: Stimulus Response Monitor and Switching Unit (Building Block) Selection Programming

To facilitate control of the Building Blocks external to the AN/GJQ-9 the external address system may be used. A unit would be required to convert serial information on the external address lines to parallel information suitable for programming the Building Blocks.

2. Function: Test Result Memory

To improve diagnostic capabilities of the test system, a unit capable of storing test results could be added. This unit would receive test result information from the AN/GJQ-9. The test result memory unit would feed its stored information to the comparator via the 13 bit digital input that is provided. The patterns of test results could then be pre-arranged failure patterns inserted into the comparator as limits. Although this function allows greater diagnosis, it requires modification to gain access to test results in the AN/GJQ-9 and could introduce some programming problems.

2.1.4.5 (contd)

The previously described AN/GJQ-9 modifications will allow it to operate the General Purpose Automatic Test Equipment (Control Computer operation excluded) but limited system capabilities still exist. Control of the building blocks can be accomplished and end items can be serviced provided their test requirements do not exceed the limit capability. Areas where serious limitations exist are presented below:

1. Voltage A/D Converter

   A. The D.C. function of the A/D converter is adequate for all but a very few high accuracy, low level voltage measurements, and will satisfactorily measure the outputs of response monitors which produce a D.C. voltage proportional to some signal characteristic.

   B. The A.C. function is inadequate for voltage tests, especially in the low level area and for signals above 5 KC. The accuracy is totally inadequate for confidence or repair tests on building blocks with output signals in this area.

   C. The resistance function does not meet the system requirements over the entire measurement range.

2. Counter - Timer

   A. The range and accuracy of frequency measurements is inadequate for measurements utilizing the transfer oscillators of the automatic test system.

   B. The range and accuracy of frequency measurements is inadequate for most direct frequency measurements above 1 KC and below 1 MC.

   C. The counter is incapable of performing confidence tests on stimulus generators of the automatic test system.

   D. Time interval and pulse width measurements required of the automatic test system are beyond the range and accuracies of the counter-timer.

3. Display, Printout, Comparator

Three significant digits of comparison, display and printout are insufficient for counter-timer measurements encountered using the automatic test system.

2.1.4.5 (contd)

4. Logistics Data Output

There is no provision for insertion of end item identity into the automatic test system so the matching of end item identity and data output will be a manual procedure. The particular end item will have to be associated with a particular test number for end item search purposes. This requires assigning sequences of test numbers to end items, a totally unsatisfactory procedure when the number of tests on each end item, the number of end items at different depots, and the number of required test tapes are considered.

5. Computer Control

The system using a modified AN/GJQ-9 could have capabilities of transmitting information from the tape to the Control Computer via the external assessory output. However, the automatic test system with Control Computer uses the capabilities of the Programmer-Controller (under direction from the C/C) to conduct the tests. This requires an input on the Programmer-Controller which parallels the tape information input, so that the C/C can operate the system. A modified AN/GJQ-9 as previously described lacks this feature.

6. Operators Efficiency

Lack of system controls and display panels at each test bench will increase an operators labor for performance of depot servicing.

2.1.5 Test Bench

Operations or tasks to be performed at the test benches of Figure 4 are:

1. Connection of the cables between the UUT and GPATS to the ATE.
2. Substitution of good modules for defectives ones.
3. Setting or making potentiometer adjustments, tuned circuit adjustments, etc.
4. Storage of mechanical parts removed from UUT during hook-up.

The operations of inserting tube socket or etched card connector adapters, TEE connectors, clip leads, and test point plugs can be done before the unit arrives at the bench by use of suitable UUT-to-GPATS adapter cable assemblies. Replacement of defective components also can be done away from the test bench. This means practically no work surface is required at the test bench.

2.1.5 (contd)

Portable test benches are recommended to allow for pre-interconnecting the black box or module to be serviced away from the test equipment. In this manner the preparation time at the test equipment is kept to a minimum. Two sets of UUT-to-GPATS adapter cables are required. The portable unit also serves as a convenient transport for heavy systems, thus reducing the chance of UUT, adapter or hook-up cables damage due to improper handling and dropping.

A lower shelf provides additional space for placement of special accessories.

2.1.6 Peripheral Equipment

Equipment located adjacent to the Programmer-Controller, building block racks and test benches is required primarily for performance of functions supporting the equipment which services the end items. When required this equipment will function as a Computer-Controller, directing tests and making test result decisions for the several Programmer Controllers with which it is associated.

Wires utilized for transfer of information between a Programmer-Controller and the time shared peripheral equipment are shown in Figure 4

Some uses of the peripheral equipment are listed below. See Section 2.3.

1. Logistics Data Generation
2. History of units by serial number
3. Reliability studies
4. Test equipment logistics
5. Overhead logistics
6. Production Control
7. Machine load forecast -pre-production,production scheduling
8. Automatic tape preparation
9. Code conversion
10. Updating test tapes
11. Debugging test programs
12. Making computations as required in test procedures
13. Assembling its own programs
14. Assembling programs for ancillary units
15. Performing tests where self program modification is required

2.1.7 Special Accessories

Special test items whose characteristics are different than those exhibited by the defined building blocks of Appendix 2-45 will be

2.1.7 (contd)

required for servicing some end items. See Figure 4 . Most of these are unique, special purpose items which have been previously defined and developed for end items already serviced by depots. Use of the special test items would be considered during preparation of automatic test programs for the end items DAAFD personnel include in the initial use of GPATS.

Most of the special test items would be attached to the UUT during hook-up of the cables and adapters. The limiting factor on this would be the size of the accessory, or the input/output switching requirements determined necessary for proper servicing of the end item.

2.1.8 Common Building Block Lines

Modification of the quantity or type of assembled building blocks by addition to or deletion from those assembled building blocks is of primary importance as this is a factor affecting the flexibility and versatility of the General Purpose Automatic Test System. It must be performed with a minimum of operator decisions and labor.

A trunk line method for input/output lines performing identical functions in all building blocks is recommended. These lines, designated common building block lines, may be looped from building block to building block if a dual connector scheme is included in each building block. See Figure 4.

1. AC Power

The quantity of building blocks on each A.C. power feeder line is a function of allowable line losses and balancing of three phase lines utilized for single phase power.

2. Bench Identity

Bench identity information will dictate to all building blocks that bench where end item servicing is being performed at that time.

3. Building Block Identity

Building block identity, coded information present on seven parallel lines will define the particular type of building block to be programmed. Each type will have an assigned 7 digit coded address. Decoders, preset by switches to the correct code, will be in every building block. See Appendix 46 Section 2.16 for decoder specification.

2.1.8 (contd)

4. Building Block Sub-identity Code

When more than one of a type of building block is required for a test set-up, this coded parallel 4 line bus will identify the specific one of a type to be programmed. The same decoder as presented in Paragraph 2.1.8.5 will be utilized. Two sets of switches are required. Bench identity information of paragraph 2.1.8.2 will determine which set of switches is presetting the decoder. After the decoder determines coincidence between preset values and information on the 11 line bus , a program enable signal is generated.

5. Programming Information

Parallel lines common to all building blocks will supply programming information. Upon receipt of a program enable signal from the decoder, paragraph 2.1.8.4, the quantity of lines required to program the building block will be sampled and information present will be stored in a program memory unit. Specifications for this program memory unit, required in all building blocks, appear in Appendix 46 . Functions shall remain as programmed until a release (reset) command is received.

Programming information shall be in Binary Coded Decimal form weighted (8-4-2-1).

Twenty programming lines shall be provided. If this 5 digit capacity is inusfficient to program all functions, circuitry internal to a building block shall sample the first 4 bit digit of that data block, decode it, and direct the following 4 digits to the correct program memory units. The next data block, directing program information into other program memory units will increase the capability to 8 or 9 digits. A 33 digit capacity, more than sufficient for programming any building block defined during this contract, is obtainable by this process.

6. Iteration Command

Iteration, described in Appendix 46 , shall be commanded by a signal on this line. Information on this line shall work in conjunction with program enable signals to advance one programmed function of a building block one step.

2.1.9 <u>Uncommon Building Block Lines</u>

Connection of command and input/output leads must be performed according to instructions furnished the operator. These connections must be checked and modified as required whenever end items are changed.

Specifications presented in Appendix 46 contain requirements for connections of this category.

2.1.10 Fail Safe Requirements

A GPATS must include fail-safe features that initiate an emergency shutdown when a major malfunction occurs. This shutdown should affect only those areas of GPATS that may be damaged by the malfunction. Visual indicators are required to aid an operator to isolate the malfunction.

2.1.11 Maintenance Philosophy

Maximum usage of GPATS is partially dependent upon the ease and time required to determine that malfunction(s) are present, the time to isolate the malfunction(s), and the time to repair the malfunction(s). In the following material, confidence tests, or tests to determine the building blocks operational status, are treated separate from tests for repair of defective building blocks and modules. Contractors must supply instructions, cables, adapters and test programs for utilization of GPATS to perform these tests. Suitable test points, readily available, are required. Only the Programmer-Controller, 10 mc frequency counter, digital multimeter, power meter, waveform analyzer and switching units should be used for maintenance tests unless a contractor proves other building blocks are necessary.

To minimize down time as a result of malfunction, it is imperative that a depot utilizing GPATS accumulates a sufficient stock of spare piece parts to support the General Purpose Automatic Test System. Standardization procedures followed during the development of GPATS can greatly reduce the quantity of piece parts required.

2.1.11.1 Determination of Operational Status

Confidence tests may be performed periodically or after some NO-GO signals when GPATS is servicing end items. By minimizing types of building blocks required for confidence tests it is possible to connect the necessary cables as the building blocks are assembled. Extra switching units would be necessary to gain this advantage of shorter time requirements for performance of a confidence test.

In general, response monitors will require standards for operational status determination. These standard test signals may be an integral part of the building block or externally supplied by standards which depots have at the present. However, GPATS response monitors should be sufficient for check-out of most stimulus generators and switching units if this approach is followed by all contractors.

Failure of a confidence test may indicate a defective cable, building block, or it may indicate a misaligned building block. Simple alignment procedures, preferably using front panel controls, may correct the malfunction. Then the building block would pass a repeated confidence test and servicing of end items could continue.

2.1.11.1 (contd)

Assumptions of GPATS down-time due to malfunctions have been considered during all phases of this study. Procedures for scheduling end items, Section 2.6.4.1, allows for a 70% GPATS efficiency, although malfunction downtime is just one factor contributing to this figure. Adherence to the production schedule may determine whether it is desirable to utilize GPATS at that time for piece part isolation, or even for defective module isolation, if spare operating building blocks are available.

2.1.11.2 Repair of Defective Building Blocks

After confidence tests have isolated the defective building block of the General Purpose Automatic Test System, it must be decided whether to utilize the same GPATS set-up for repair or to use a second 100% operating GPATS set-up at a later time. Another factor affecting this decision besides that presented in the above paragraph is that some building blocks, such as a multimeter, will require an operating multimeter for defective module isolation.

Maintenance procedures identical to that assumed for servicing end items will be used. First a defective module will be isolated and then piece part isolation will be performed. As in paragraph 2.1.11, the contractor must supply instructions, cables, adapters and test programs for utilization of GPATS.

2.1.11.3 Standards for Building Block Confidence Tests

Output signal tolerances of the specified building blocks have been tabulated. Figure 9 presents output characteristics versus the tolerance required for that characteristic of the building block. Frequency tolerances are presented in Figure 10(a) instead of Figure 9 because the tolerance information is defined in a different manner.

From this data it is evident that a voltage standard better than 0.1%, a frequency standard better than 1 part in 10^7 per week and a power standard greater than 1% are required for primary GPATS standards. These represent the major standards requirements.

When building blocks are utilized as secondary standards for checkout, calibration, or verification of operational status of other building blocks, a specified dependency sequence must be determined and followed by GPATS operating personnel. Thus units having relatively wide tolerance characteristics cannot be standards for calibration or checkout of building blocks requiring tighter specifications. Figures 10(b),(c) and (d) present building block secondary standard, or calibration, dependency upon a primary voltage standard, a primary power standard and a primary frequency standard.

The quantity and hook-up problems of primary standards can be minimized by this procedure.

OUTPUT TOLERENCE

.1% - .4%	.4% - 1%	1% - 4%	4% - 10%	10% - 100%
OSCILLATOR 0.1CPS - 30KC		OSCILLATOR 40MC - 400MC (POWER)	NOISE GENERATOR 50, 70, 100 & 300OHMS (POWER)	OSCILLATOR 950MC - 1250MC (POWER)
PULSE GENERATOR (PULSE AMPLITUDE)		IMPEDANCE METER	RESISTIVE LOAD (RESISTOR TOL.)	OSCILLATOR 8.5GC - 12.4GC (POWER)
DIGITAL MULTIMETER (AC & DC)		POWER METER & REFLECTOMETER (POWER)	INDUCTIVE LOAD (INDUCTOR TOL.)	OSCILLATOR 2.6GC - 3.9GC (POWER)
POWER SUPPLY 0.1V - 35VDC		WAVEFORM ANALYZER (AM DETECTOR) (PEAK DETECTOR)	CAPACITIVE LOAD (CAPACITOR TOL.)	OSCILLATOR 12.4GC - 18.0GC (POWER)
POWER SUPPLY 22V - 32VDC		SPECTRUM ANALYZER (OUTPUT FREQ.)		PEAK POWER METER (POWER)
POWER SUPPLY 30V - 500VDC		POWER SUPPLY 500V - 6000VDC		
		3 AC SUPPLIES 400CPS		
		AC SUPPLY 30CPS		
		OSCILLATOR 30KC - 40MC		

Figure 9. Building Block Characteristic Tolerance Tabulation

Figure 10(a) Building Block Frequency
Tolerance Tabulation

FREQUENCY TOLERANCE

1 TO 10 PTS IN 10^7 PER WK	1 TO 10 PTS. IN 10^6 PER WK	1 TO 10 PTS IN 10^5 PER WK	1 TO 10 PTS IN 10^4 PER WK	1 TO 10 PTS IN 10^3 PER WK	1 TO 10 PTS IN 100 PER WK
PULSE GENERATOR 10MC OSCILLATOR	TRANSFER OSCILLATOR 475MC - 1525MC	OSCILLATOR 30KC - 40MC	OSCILLATOR 0.1CPS - 30KC		WAVEFORM ANALYZER PULSE WIDTH, RISE, & FALL TIME
DELAY GENERATOR 10MC OSCILLATOR	TRANSFER OSCILLATOR 1.475 - 10.5GC	OSCILLATOR 40MC - 400MC	OSCILLATOR 12.4 - 18.0GC		SPECTRUM ANALYZER SWEEP FREQUENCY
TIME INTERVAL & FREQUENCY METER 10MC OSCILLATOR		OSCILLATOR 950MC - 1.25GC			AC SUPPLY 400CPS - PHASE REFERENCED
TRANSFER OSCILLATOR 5MC - 175MC		OSCILLATOR 8.5GC - 12.4GC			AC SUPPLY 400CPS
TRANSFER OSCILLATOR 165MC - 605MC		OSCILLATOR 2.60 - 3.95GC			AC SUPPLY 400CPS 6.3V
		IMPEDANCE METER OSCILLATORS			

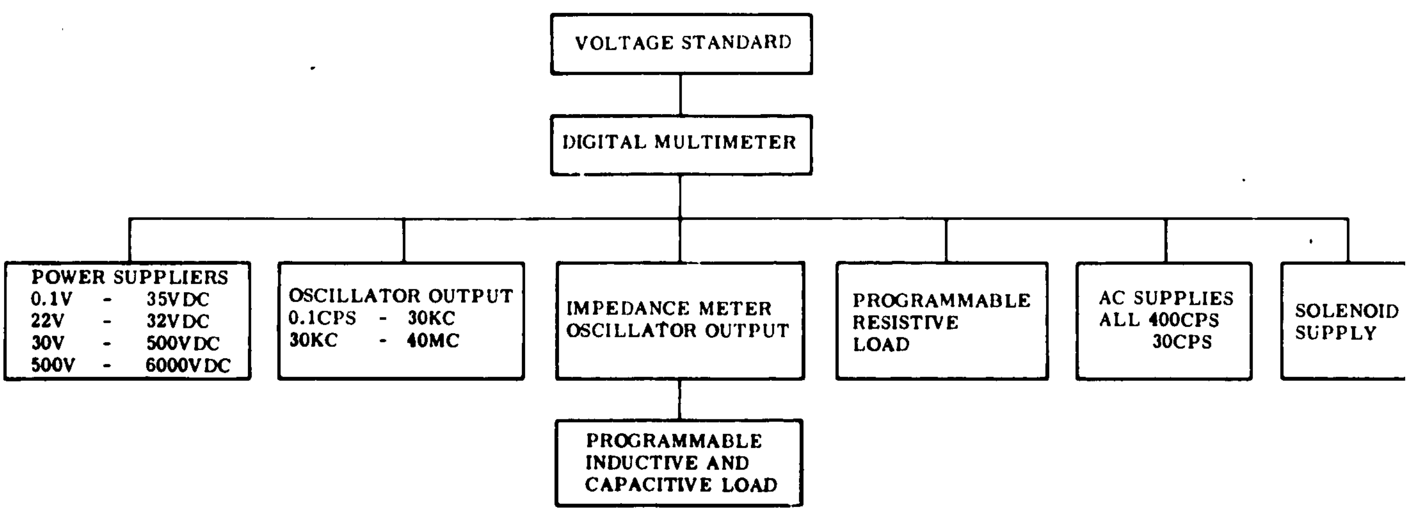
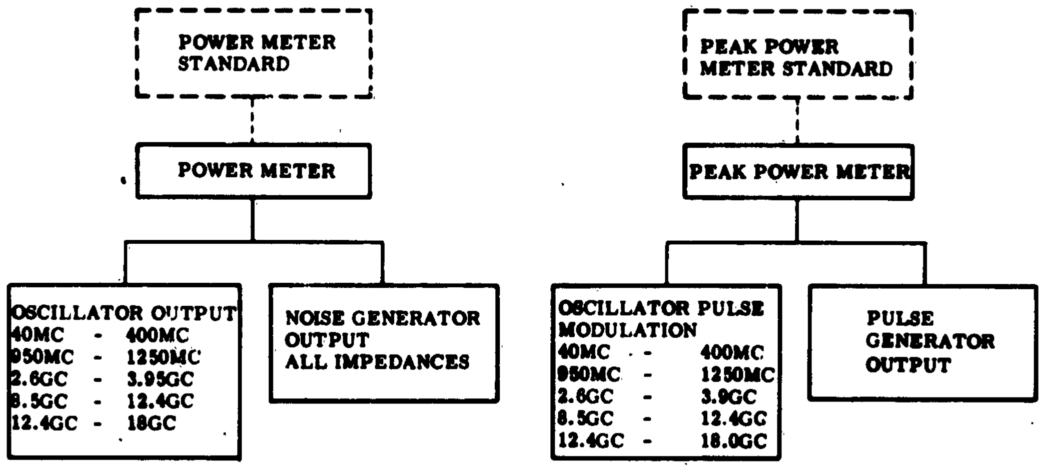


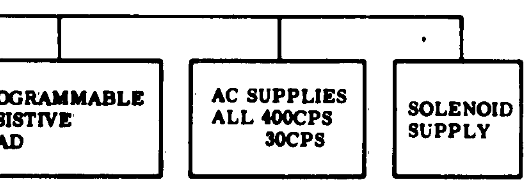
Figure 10(c) Building Block Dependency-
Power Standard

Building Block Frequency Tolerance Tabulation

TO 10 PTS 10^3 PER WK	1 TO 10 PTS IN 100 PER WK
	WAVEFORM ANALYZER PULSE WIDTH, RISE, & FALL TIME
	SPECTRUM ANALYZER SWEEP FREQUENCY
	AC SUPPLY 400CPS - PHASE REFERENCED
	AC SUPPLY 400CPS
	AC SUPPLY 400CPS 6.3V

Figure 10(b) Building Block Dependency-
Voltage Standard





Building Block Dependency-
Power Standard

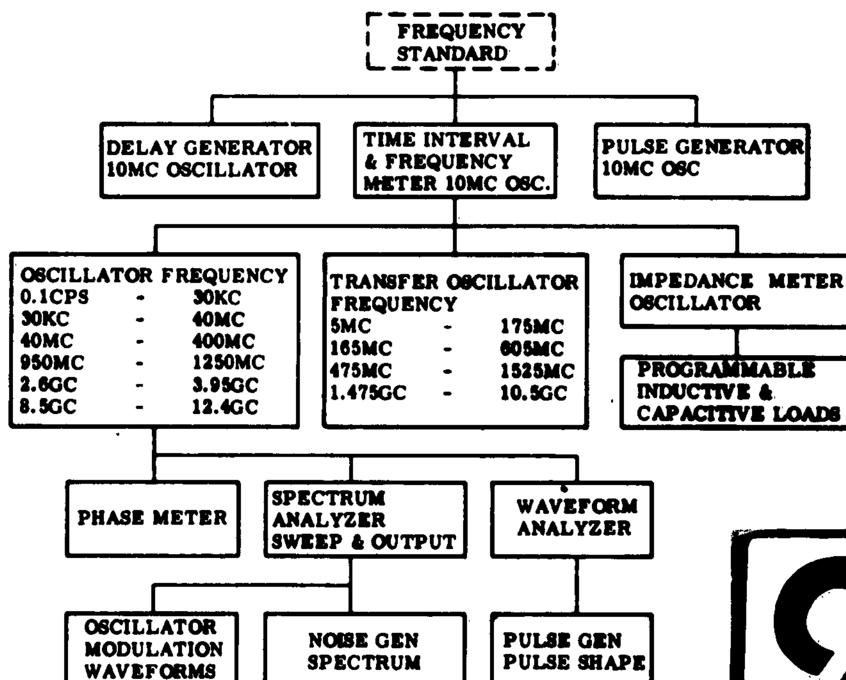


Figure 10(d) Building Block Dependency-
Frequency Standard

2

2.1.11.3 (contd)

Use of existing depot standards should be considered, although adequate new standards could be procured if a depot lacks a particular capability.

2.2 Code Conversion

2.2.1 Summary

Code conversion whereby an existing Programmer Controller tape can be processed to produce a tape for a different type of Programmer-Controller was studied as part of the study extension. Four Programmer Controllers: AN/GJQ-9, Nortronics Datico, Lavoie Robotester and General Dyanmics SCATE were considered.

One approach to code conversion is use of a computer. A general purpose digital machine, suitably programmed and equipped with tape readers and punches can convert from one P/C code to another when comparable functions exist in both P/C's. The computer program can also delete tests when converting from a complex P/C tape to a simpler P/C tape. However, use of a custom designed Code Converter rather than the computer technique is favored for the following reasons:

A. Additional input-output devices required for a general purpose computer.

B. High programming skill level required for a computer.

C. Scheduling problems involved with the computer.

D. Code conversions can be combined with manual tape program preparation operations in a single, easy to use unit.

The last reason is considered the strongest argument for a new device. By means of a test program keyboard, tape sequences can be modified to any extent desired during conversion. Also completely new tapes can be made up with relative ease. A complete performance specification for this type unit is included. Although the unit specified can be used to prepare and read Robotester tapes, it does not convert to or from Robotester format using another P/C code. The Robotester functions are limited in comparison to the other P/C's and conversion does not appear practical in this case.

Included in this section is a suggested IBM format for use by a prime equipment manufacturer in listing test data for his electronics unit. Extracting test data for an ATE test program from present Technical Manuals is a laborious and difficult process. In future prime equipment procurements, test data can be furnished in a much more useful and complete format.

2.2.2 Code Converter Tape Program Preparation Unit

A complete performance specification for a Code Converter is included in Appendix I . This specification describes a Code Converter tape program preparation unit which will fully meet the depot's programming requirements using existing Programmer Controllers. This specification can be easily extended to include the time shared P/C described in this report by adding the requirement for an additional decoder and encoder. The keyboard, data storage, input and output devices and displays would remain unchanged.

The Code Converter described in the specification will provide for conversion from one selected P/C code to another within limitations imposed only by the P/C capabilities themselves. For example, the AN/GJQ-9 has a programmed time ADC comparator not found elsewhere. The Datico has 5 digit limits, AN/GJQ-9 and SCATE use 3 digit limits. Robotester does not use programmed limits at all but uses a programmed measured value with limits expressed as percentages of this measured value. The Code Converter specification does not call for converting Robotester tapes to other tapes or conversion from other tapes to Robotester tapes as this is not considered practical because of limit and measured value computations involved and because of the relatively limited performance capability of the basic Robotester. However, the specification does provide for preparation, duplication, verification and modification of Robotester tapes. Converting from Robotester tapes to other P/C tapes would require multiplication capability to arrive at digital limits by multiplying the Robotester tape measured value by its tolerance (expressed as a decimal number rather than a percent). Other test data such as timer value and stimulus switching commands would have to be added by keyboard or other means to the test sequence. If converting to Robotester tapes from Datico tapes, for example, the Robotester measured value could be calculated from Datico high and low limits as the average of high limit + low limit. Percent tolerance for the Robotester tape could then be calculated as $\frac{\text{High limit - low limit}}{\text{High limit + low limit}} \times 100$

This value must be rounded off to 5, 10 or 20%. As stated above, it is not considered practical to burden the Code Converter with this calculation or approximation.

The Code Converter as specified can automatically convert stimulus and test point relay selection commands from one tape to another. However this requires consideration of test point and stimulus relay adapter cable wiring for the unit under test. Wiring of a Datico adapter cable and an AN/GJQ-9 adapter cable for the same unit under test must allow scanner test point number 1 in the AN/GJQ-9 to connect to the same point that connected to Datico test point 1 through its peculiar adapter cable. If adapter cable wiring does not correspond, the Datico tape information for test point selection can be deleted and by means of the Code Converter keyboard, the desired AN/GJQ-9 test point assignment can be made.

2.2.2 (contd)

The Code Converter does provide for differences in basic punched tape formats. For example, the tape level or channel reserved for parity differs in SCATE and AN/GJQ-9. Also, the AN/GJQ-9 and Datico use one row at a time programming while SCATE and Robotester use data block programming. The specification calls for a data storage function which allows for these variations. Several rows of tape information or even several data blocks can be read off the input tape into data storage. From data storage, the information can be read out in a different order or sequence as required for the output tape.

A typical Datico test (Test 164 Handbook of Test Instructions AN/ARC-27 Service Section) uses the following order of test data in the test sequence:

1. Test number
2. Stimulus selection
3. High limit
4. Low limit
5. Measurement type
6. Test point selector
7. Conversion command
8. Stimulus selector
9. Start back up timer, wait for coincidence

The corresponding sequence for SCATE-203 would be:

1. Test number
2. Stimulus selection
3. Measurement type
4. Test point, distribution point selection, group 1.
5. Low limit
6. High limit (Conversion Command is automatic and initiated by a delayed high limit address)
7. Stimulus selector
8. Timer reset
9. Start timer

Inherent Programmer Controller differences will result in the elimination of some test data and some entire tests when converting from one P/C tape to a simpler P/C tape. When converting from a simple P/C tape to a more complex P/C tape, additional test data or complete tests may be inserted by using the specified keyboard.

The specification provides for a printout of all test data for each test sequence on an input tape. This will be useful for verification and identification of information on old tapes or newly made tapes. Display of tape information added from the keyboard will also be possible with the

2.2.2 (contd)

printer described. During a tape to tape conversion, a data block consisting of one or more rows of tape information (from one address to the next address) will be read into data storage. This input tape data can also be printed out. It will not yet be converted and transferred to the output tape unless commanded by the operator. If the operator, by means of the keyboard, changes or adds to this data in data storage, a second printout will occur. The tape punch can then be activated, punching the modified data into the output tape.

Tape preparation for any of the four Programmer Controllers will be possible using the keyboard. It will enable setting up a complete test sequence including test number, type measurement, range, test point selection, limits, etc., before actual tape punching occurs. This is due to the data storage capacity specified, which can accommodate the lengthiest test sequence possible for each of the P/C's. The operator can have a printout of the test sequences before punching to visually check for omissions or errors. Upon punch command, a series of data blocks, in correct order will be punched, corresponding to the data storage information.

2.2.3 <u>IBM Card Format for Prime Equipment Manufacturer Use</u>

The overall approach to valid and economical test program preparation should capitalize on the prime equipment manufacturer's design and testing experience on his own product. It is recommended that documentation requirements of prime contracts eventually include test data in a form much more applicable to an automatic test system than occurs at present. This will require furnishing the prime contractor a description of the automatic test system to be used and having prime equipment test and maintenance procedures engineered using the ATE system capabilities and building block performance characteristics. It is considered that limits on testing can also be best determined by the prime equipment manufacturer. The design engineer normally tests his circuits to the point of failure by power supply voltage variation and component value variation.

He must do this to properly specify power supply, component values and input-output signal tolerances.

The design engineer must further prepare factory test procedures and furnish information for maintenance manuals. Because of these factors, the prime contractor is considered to be the best source of basic test data which will be ultimately assembled into ATE test routines. Basic test data that can be furnished by the prime contractor includes:

2.2.3 (contd)

1. Unit number by Air Force designation as determined by T.O. 00-25-06, Technical Manual, Field Maintenance Shops, "Communication, Armament and Electronic Equipment Work Unit Code Manual" and subsequent revisions thereto.

2. Type of measurements must be recorded, including parameter, high, low limit and nominal value, as well as connectors and pins used for test point and test point common connections. When three connections are needed, as for ratio measurement, two active test points and a common pin must be identified. It is also recommended that the prime equipment manufacturer assign test numbers as a means of relating measurement IBM cards to stimulus, load or power requirement IBM cards for the test in question. Three or four digit preliminary test numbers can be used with these test data cards. The depot ATE programmer can add one or two additional digits to these preliminary test numbers for identification of a particular manufacturer's unit among several diverse units whose test programs may be on a single depot tape program.

   An IBM format recommended for measurement data and test points is shown in Figure 11 . Six digits for nominal value and limits of all measurements except frequency are considered necessary for existing equipment and future advances in measurement resolution. However, allowing eight digits anticipates a 100 MC counter ATE system and future measurements of 1 part in 10^8 accuracy.

3. A.C. power requirements can be recorded using the IBM format of Fig. 12 The tests requiring this A.C. power are noted by a range of test numbers. A voltage tolerance entry is also included as the list of building blocks includes coarse and fine regulated AC units. Required warm up time for the unit under test to stabilize is entered. This is interpreted as delay time or timer value, to be programmed immediately preceding the first test number using the A.C. power.

4. D.C. power requirements can be tabulated on IBM cards using the IBM format of Figure 13 . This format is similar to that used for A.C. power data.

5. Stimulus requirements from audio or R.F. signal generator building blocks are listed on the format shown in Figure 14 . Here again, the range of test numbers discloses when during the sequence the generator output is applied. If the same signal is required for more than one test, the obvious procedure is to run these tests consecutively. If this is not feasible, an additional card can be used to signify the break in test number sequences.

2.2.3 (contd)

6. A card format for pulse generator stimulus is shown in Figure 15 and Figure 16 . Possible complex pulse pattern definition cannot be adequately described using a format common to sine wave generators, accounting for this second stimulus card format.

   Sheet 1 of pulse stimulus requirements format describes single pulse or recurrent pulse burst requirements. Fields 21 - 28 give period in seconds. This is the time measured from the leading edge of one pulse to the leading edge of the next pulse, whether the two pulses occur singly or as the first two pulses in a burst. Entries in fields 46-53, give pulse group period in seconds. When single pulses occur, this entry is not applicable. In this case it would be the same as pulse period, considering the group as a one pulse group. When pulse pairs or triplets or other pulse bursts occur, fields 46-53 give the time interval from the start of one burst to the start of the second similar burst. The pulse shape description determines whether the function generator building block is needed in addition to the pulse generator for trapezoidal or sawtooth waveforms. The pulse group number, fields 43-45 is used in event a pulse pattern is composed of recurrent diverse groups, with pulses in each group differing in width and spacing. For example, a burst of half microsecond pulses spaced one microsecond apart may be followed at a fixed time interval by a burst of 3 microsecond pulses spaced 5 microseconds apart in an alternating, recurrent fashion. Two sheet 1's would be used to describe each burst separately. Sheet 2 would give the time relationship of burst 1 to burst 2. Sheet 2 also allows for recording of modulation information such as sinusodial amplitude modulation or PRF rate frequency modulation. A pulse train code can also be recorded in the 30 spare fields. However, it is expected that few sheet 2 formats will be used.

7. Figure 17 is a suggested format for load requirements. Unless the contractor notifies the Air Force otherwise, it will be assumed that load power ratings are within the load building block specifications.

For the seven types of card formats described, field 6 can be used to identify one of the seven categories listed above. Fields 7 and 8 can be used to identify more than one card of information associated with a particular basic card. For example, to fully describe a digital measurement will require voltage level information at a number of test points, certainly greater than three. Other associated cards may list connector type by federal stock number or cable information. Still other cards may correlate ATE test point assignment to UUT connector pins.

Figure 11

IBM Format for Type Measurement

Field	Data
1 - 5	Air Force Unit number
6	Letter code for type measurement
7 - 8	Card number 1 - 99
9	Hundred thousands digit, test number
10	Ten thousands digit
11	Thousands digit
12	Hundreds digit
13	Tens digit
14	Units digit
15 - 22	Type measurement Volt DC (voltage DC) Volt AC Res 2 (resistance 2 wire) Res 4 (resistance 4 wire) Ratio DC Ratio AC In phase (in phase component of complex waveform) Quad (quadrature component of complex waveform) Freq (frequency) Period Width Series RC Series RL Par RC (parallel RC) Par RL (parallel RL) Capacity Induct (inductance) Time Ratio Events Power PK (Peak power) Power AV (Average power)

Figure 11 (contd)

Field	Data
15 - 22 (contd)	Digital Imped (Impedance) Rise Time Fall Time Volt PK (Peak voltage) Slope Phase
23	Ten millions digit, high limit
24	Millions digit
25	Hundred thousands digit
26	Ten thousands digit
27	Thousands digit
28	Hundreds digit
29	Tens digit
30	Units digit
31 - 38	Same data as 23 - 30 for low limit
39 - 46	Same data as 23 - 30 for nominal value
47 - 49	Multiplier, as K for kilo, M for milli, U for micro, UU for micro micro, N for nano, MEG for meg or mega
50 - 52	Unit, as V for volt, OHM, C for cycle, W for watt, SEC for second, DEG for degree, FD for farad, HY for henry, VS for volt-seconds.
53 - 57	Test point connector or connection for line 1, as P, J, TP, TB, V, Q, T, R, C, L, number designation
58 - 60	Above connector pin or connection terminal letters or number
61 - 65	Test point common connector or line 2 connection

Figure 11 (contd)

Field	Data
66 - 68	Above connector pin or connection point
69 - 73	Test point reference or line 3 for ratio tests, time interval stop input
74 - 76	Above connector pin or connection point

Figure 12

IBM Format for A.C. Power Requirements

Field	Data
1 - 5	Air Force unit number
6	Letter code for A.C. power
7 - 8	Card number 1 - 99
9	Hundred thousands digit, "from" test number
10	Ten thousands digit
11	Thousands digit
12	Hundreds digit
13	Tens digit
14	Units digit
15 - 20	Same type of data as 9 through 14 for "to" test number
21	Thousands digit, A.C. voltage in volts
22	Hundreds digit
23	Tens digit
24	Units digit
25	Decimal point
26	Tenths digit
27	Thousands digit, A.C frequency in cycles
28	Hundreds digit
29	Tens digit
30	Units digit
31	Multiplier, K for kilo
32	Hundreds digit, load current in amperes

Figure 12 (contd)

Field	Data
33	Tens digit
34	Units digit
35	Decimal point
36	Tenths digit
37	Multiplier, M for milliamperes, U for Microamperes
38	Tens digit, voltage tolerance
39	Units digit
40	Decimal point
41	Tenths digit
42	Percent tolerance, %, or voltage tolerance, V
43	Tens digit, frequency tolerance
44	Units digit
45	Decimal point
46	Tenths digit
47	Percent tolerance, %, or frequency tolerance in cycles, C
48	Units digit, no. of phases
49 - 53	Connector designation, P, J, or TB number
54 - 56	Above connector pin for phase 1 input
57 - 59	Above connector pin for phase 2 input
60 - 62	Above connector pin for phase 3 input
63 - 65	Above connector pin for common input

Figure 12 (contd)

Field	Data
66	Hundreds digit, warm up time in seconds
67	Tens digit
68	Units digit

Figure 13

IBM Format for D.C. Power Requirements

Field	Data
1 - 5	Air Force unit number
6	Letter code for D.C. power supplies
7 - 8	Card number 1 - 99
9	Hundred thousands digit, "from" test number
10	Ten thousands digit
11	Thousands digit
12	Hundreds digit
13	Tens digit
14	Units digit
15 - 20	Same type of data as 9 through 14 for "to" test number
21	Polarity, D.C. voltage
22	Thousands digit, D.C. voltage in volts
23	Hundreds "
24	Tens digit
25	Units digit
26	Decimal point
27	Tenths digit
28	Hundredths digit
29	Tens digit, voltage tolerance
30	Units digit
31	Decimal point
32	Tenths Digit

Figure 13 (contd)

Field	Data
33	Hundredths digit
34	Thousandths digit
35	Percent tolerance (%) or voltage tolerance (V)
36	Thousands digit, load current in amperes
37	Hundreds digit
38	Tens digit
39	Units digit
40	Decimal point
41	Tenths digit
42	Multiplier, M for milli, U for micro
43 - 47	Connector designation P, J, TP, or TB number
48 - 50	Above connector pin
51 - 55	Common connector designation
56 - 58	Above common connector pin
59	Hundreds digit, warm up time for unit under test, in seconds
60	Tens digit
61	Units digit

Figure 14

IBM Format for A.F. and R.F. Stimulus Generator Requirements

Field	Data
1 - 5	Air Force unit number
6	Letter code for A.F. and R.F. stimulus Gen.
7 - 8	Card number 1 - 99
9	Hundred thousands digit, "from" test number
10	Ten thousands digit
11	Thousands digit
12	Hundreds digit
13	Tens digit
14	Units digit
15 - 20	Same type of data as 9 through 14 for "to" test number
21	Ten thousands digit, frequency in cycles
22	Thousands digit
23	Hundreds digit
24	Tens digit
25	Units digit
26	Decimal point
27	Tenths digit
28	Hundredths digit
29	Multiplier as K for kilo, M for Mega, G for gega, blank for cycles
30	Hundreds digit, output level

Figure 14 (contd)

Field	Data
31	Tens digit
32	Units digit
33	Decimal point
34	Tenths digit
35	Hundredths digit
36	Multiplier, U for micro, M for milli
37	Unit, W for watt, V for volts
38	Hundreds digit, load in ohms
39	Tens digit
40	Units digit
41	Decimal point
42	Tenths digit
43	Multiplier, M for meg., K for kilo
44 - 46	Type modulation, as AM, FM, TM
47	Thousands digit, modulation frequency in cycles
48	Hundreds digit
49	Tens digit
50	Units digit
51	Multiplier, K for kilo, M for mega blank for cycles
52	Thousands digit, frequency deviation in cycles (FM)
53	Hundreds digit, frequency deviation

Figure 14 (contd)

Field	Data
54	Tens digit, frequency deviation or % mod.
55	Units " " " " "
56	Multiplier, K for kilo, M for mega or %
57 - 61	Connector designation, P, J, TP, or TB number
62 - 64	Above connector pin
65 - 69	Common connector designation
70 - 72	Above common connector pin
73	Tens digit, % distortion
74	Units " " "

Figure 15

IBM Format for Pulse Stimulus Requirements, Sheet 1

Field	Data
1 - 5	Air Force unit number
6	Letter code for pulse generator, sheet 1
7 - 8	Card number 1 - 99
9	Hundred thousands digit, "from" test number
10	Ten thousands digit
11	Thousands digit
12	Hundreds digit
13	Tens digit
14	Units digit
15 - 20	Same type of data as 9 through 14 for "to" test number
21	Thousands digit, pulse period in seconds
22	Hundreds digit
23	Tens digit
24	Units digit
25	Decimal point
26	Tenths digit
27	Hundredths digit
28	Multiplier, U for micro, M for milli
29	Polarity of pulse
30	Hundreds digit, peak amplitude in volts
31	Tens digit
32	Units digit

Figure 15 (contd)

Field	Data
33	Decimal point
34	Tenths digit
35	Thousands digit, pulse width in seconds
36	Hundreds digit
37	Tens digit
38	Units digit
39	Decimal point
40	Tenths digit
41	Hundredths digit
42	Multiplier, U for Micro, M for milli, N for nano
43	Hundreds digit, no. of pulses per group
44	Tens digit
45	Units digit
46	Thousands digit, period of similar pulse groups in seconds
47	Hundreds digit
48	Tens digit
49	Units digit
50	Decimal point
51	Tenths digit
52	Hundredths digit
53	Multiplier, M for milli, U for micro
54	Tens digit, identification number of pulse group whose characteristics are listed

Figure 15 (contd)

Field	Data
55	Units digit
56 - 60	Connector or connection to which pulse is applied, as P, J, TB designation
61 - 63	Above connector pin
64 - 68	Common connector or connection designation
69 - 71	Common connector pin or connection terminal
72 - 73	Pulse shape, RECT for rectangular, SAWTTH for sawtooth, TRAP for trapezoidal

Figure 16

IBM Format for Pulse Stimulus Requirements, Sheet 2

Field	Data
1 - 5	Air Force Unit Number
6	Letter code for pulse stimulus, sheet 2
7 - 8	Card number 1 - 99
9	Hundred thousands digit, "from" test number
10	Ten thousands digit
11	Thousands digit
12	Hundreds digit
13	Tens digit
14	Units digit
15 - 20	Same type of data as 9 through 14 for "to" test number
21	Thousands digit, dissimilar pulse group spacing in seconds
22	Hundreds digit
23	Tens digit
24	Units digit
25	Decimal point
26	Tenths digit
27	Hundredths digit
28	Multiplier as U for micro, M for milli, blank for seconds.
29	Hundreds digit, indentification number of pulse group considered as time reference group
30	Units digit

Figure 16 (contd)

Field	Data
31	Dash
32	Hundreds digit, identification number of dissimilar pulse group whose time relation to first group is being described
33	Units digit
34 - 36	Type modulation as AM, FM
37	Ten thousands digit, modulation frequency in cycles
38	Thousands digit
39	Hundreds digit
40	Tens digit
41	Units digit
42	Ten thousands digit, PRF deviation in cycles
43	Thousands digit
44	Hundreds digit, PRF deviation or % modulation
45	Tens digit
46	Units digit
47	Percent (%) or C, cycles

Figure 17

IBM Format for Load Requirements

Field	
1 - 5	Air Force unit number
6	Letter code for loads
7 - 8	Card number 1 - 99
9	Hundred thousands digit, "from" test number
10	Ten thousands digit
11	Thousands digit
12	Hundreds digit
13	Tens unit
14	Units digit
15 - 20	Same type of data as 9 through 14 for "to" test number
21	Thousands digit, load value
22	Hundreds digit
23	Tens digit
24	Units digit
25	Decimal point
26	Tenths digit
27	Hundredths digit
28	Thousandths digit
29 - 30	Multiplier, as K for Kilo, U for micro, UU for micro micro, and M for milli
31 - 35	Unit, as OHM, MEG (megohms), FARAD or HENRY

Figure 17 (contd)

Field	Data
36 - 40	Test point connector designation, P, J, TP or TB number
41 - 43	Above connector pin
44 - 48	Common connector designation
49 - 51	Above connector pin

2.3 Summary on Control Computer with Data Processing Capability

2.3.1 General Summary

Studies indicate that there is a requirement for a sophisticated computer type checkout device at this depot. There are requirements for data handling functions to support the automated facility. The approach recommended, and the one believed to be the most practical and economical, is to include both data processing and control capabilities in the same machine, and to integrate a group of serial type Controller Programmers into the system. Other models of the Control Computer may be fabricated for future requirements from the same drawings less only the versatile data handling facilities.

Some of the uses of the Control Computer with Data Processing Capabilities are:

1. Logistics Data Generation
2. History of Units by Serial Number
3. Reliability Studies
4. Test Equipment Logistics
5. Overhead Logistics
6. Production Control
7. Machine Load Forecast - Preproduction, Production Scheduling
8. Automatic Tape Preparation
9. Code Conversion
10. Updating Test Tapes
11. Debugging Test Programs
12. Making computations as required in Test Procedures
13. Assembling its own programs
14. Assembling programs for ancillary units
15. Performing tests where self program modification is required

Methods have been suggested in the study reports that would allow integration of existing type Controller-Programmers into the system without modification (requires dual controllable benches, See Figure 18). The same Control Computer would also be able to communicate with Controller-Programmers which were designed to become a part of a system such as required at this depot, and which would work into single controlled benches.

Speed has been sacrificed for power and ease of operation. This requires:

1. Convenient Code - 8421 BCD) See Figure 19
2. Adequate Word Size - 8 digits)
3. Versatile Instruction Family
4. Adequate Indicators of Internal Status
5. Adequate Control and Convenient Entry Mechanism
6. Indexing Facility (5 registers)

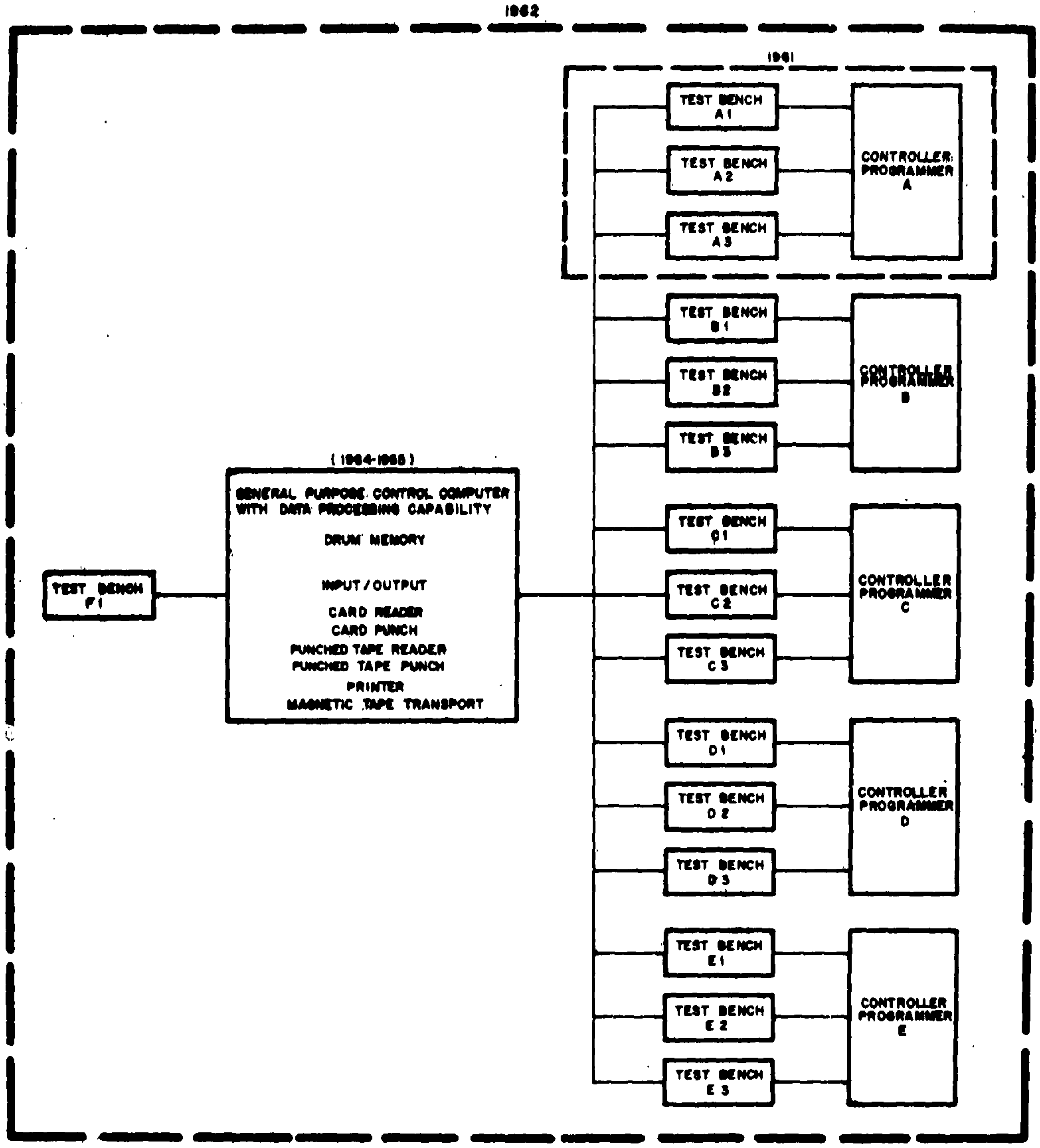
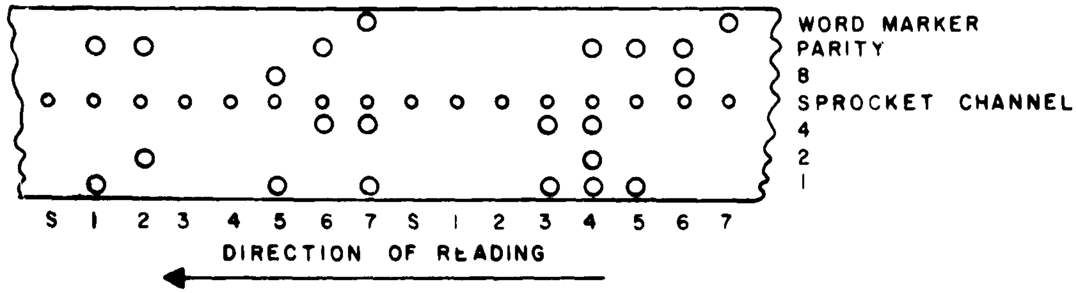


Figure 18 - Integrated Checkout Facility using Existing Controller Programmers



SAMPLE OF INPUT TAPE   TWO WORDS ARE SHOWN

THE FIRST WORD IS AN INSTRUCTION AND READS AS FOLLOWS:

OPERATIONAL CODE +012

ADDRESS 0945

THE SECOND WORD IS A DATA WORD AND CONTAINS THE NUMBER +00057180

THE INSTRUCTION WORD WITHIN THE MACHINE WILL APPEAR AS SHOWN BELOW:

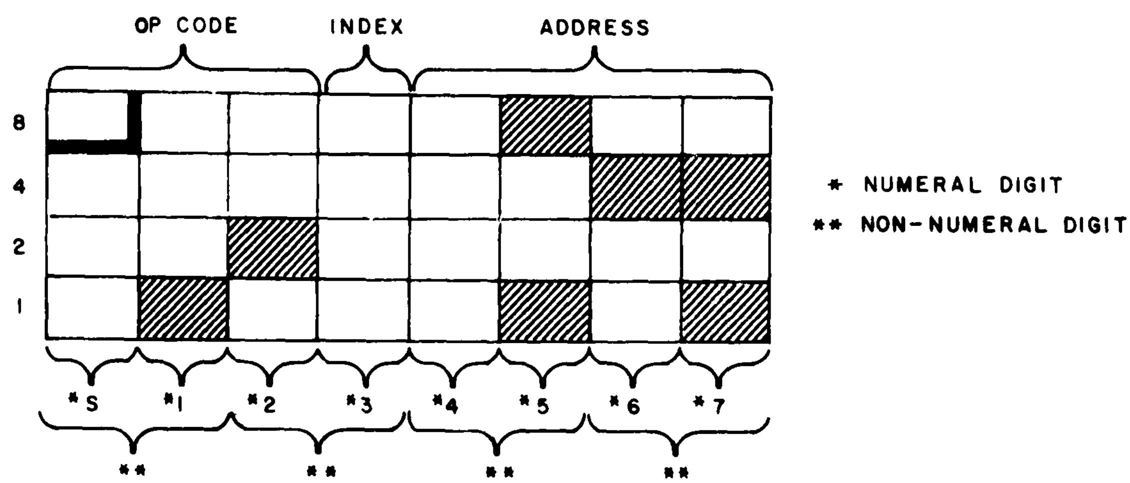


Figure 19. Input Tape Format

2.3.1 (contd)

7. Secondary Memory Magnetic Tape
8. Drum Working Memory (7500 words)
9. Common Routine Library
10. Diagnostic Programs
11. Calibration Programs

2.3.2 Conventional I/O Devices

Versatile input (I/O) output facilities are required for efficient data processing. The machine being described is called "a Control Computer with Data Processing Capability". See Figure 20.

The control function is to control automatic testing as required in the depot. Data Processing is required for the many support functions which must be performed for the automatic test facility. Although this system serves a dual purpose, it is anticipated that the two functions may not necessarily be in demand simultaneously very often. The hardward described can be used in this fashion as required. However it is more efficient to separate the two functions as scheduling permits.

A versatile and powerful Control Computer has been described. Speed was de-emphasized, the requirement being that it be capable of keeping ahead of the items it is to control. The recommended speeds of the input/output devices were in general medium. Input/output functional requirements were established from equipments relatively common in the field. It is anticipated that these input/output devices can be chosen from units already in production by two or more manufacturers.

A balanced input/output device family has been strongly recommended. For instance, a basic 8 digit word is used. The Input/output register will handle 10 such words. This is the capacity of one punched card of 80 columns. The Magnetic Tape Unit also operates in blocks of 10 words. The recommended 72 column printer may also be though of as 80 columns. 80 columns would be more desirable, but 72 columns is more standardized. This size printer will print on conventional width paper. Larger (120 column) printers may be used, as long as provision is made for sending data from the I/O Register to selected groups of columns, and that one line can have two print cycles under this condition. Processing Robotester tapes poses a problem. The computer can certainly handle these tapes if the necessary special equipment is added. That is, a 12 level reader and punch. It was shown how the Robotester and other various types of serial Controller-Programmers could be integrated into the proposed facility. If the depot chooses to do this, this punch and reader will be provided. However if the depot chooses to de-emphasize the Robotester in favor of more versatile and sophisticated serial Controller-Programmers, this facility should not be included.

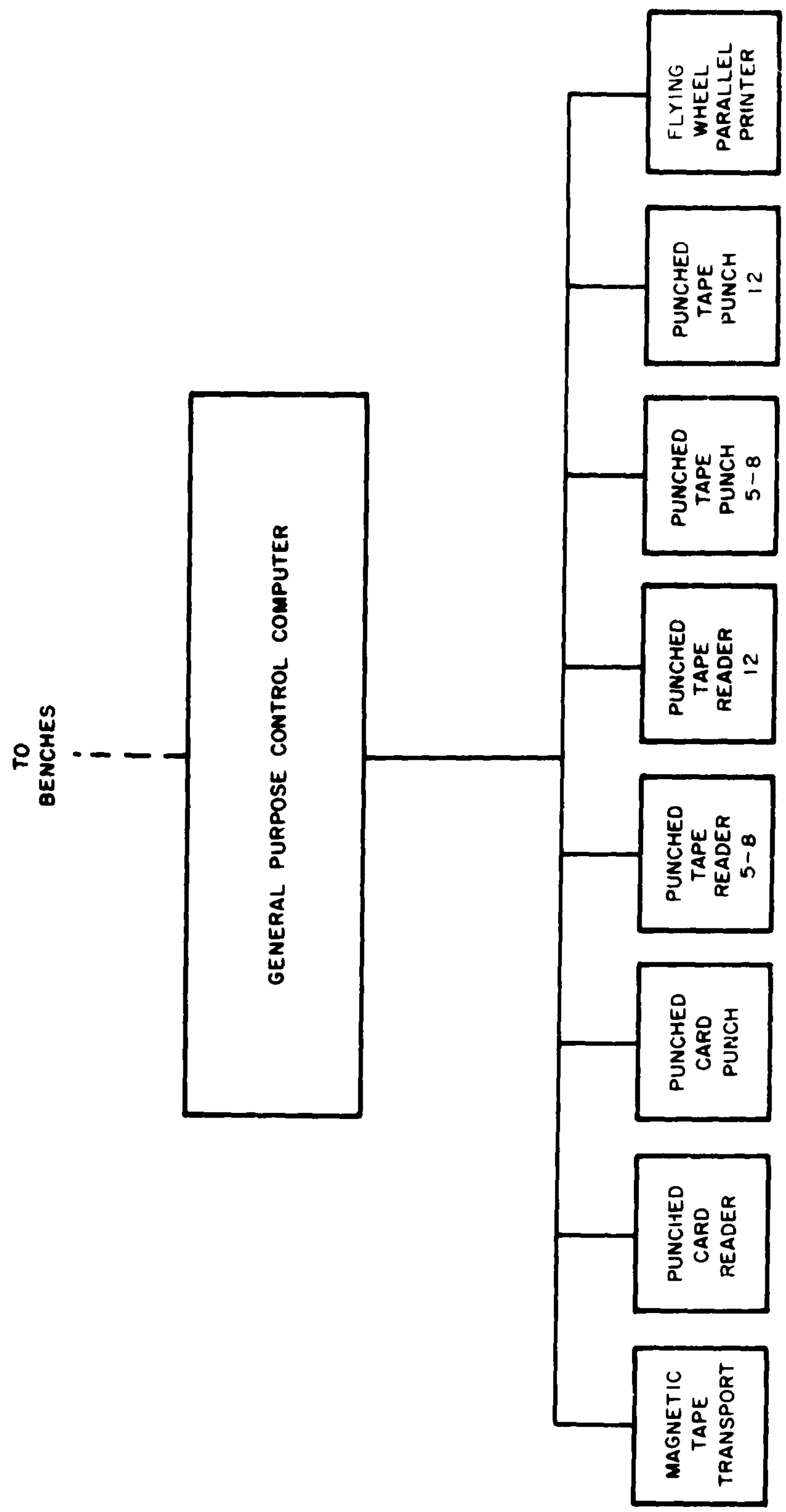


Figure 20. Control Computer with Data Processing Capability

2.3.2.1 Magnetic Tape Device

At least one Magnetic Tape device is required as a secondary memory. Controls for two units will be provided, however. Having two units will give the Computer system more versatility, but probably would not be required initially.

In describing the magnetic tape device, some external considerations should be made. The first consideration is for compatibility with other depot facilities. The tape width, channel spacing, gaps, packing density, etc. would be chosen so tapes may be inter-changed between the Test Facility Computer and other data handling equipment at the depot. Another desireable feature would be that the magnetic tape device be the same basic machine as the punched paper tape reader. This is recommended as a consideration to decrease test equipment logistics and maintenance problems. Common control features could then be shared. Several manufacturers offer basic mechanisms that can be completed for either paper or magnetic medium.

2.3.2.2 Photoelectric Punched Tape Reader

A 500 character per second tape reader is recommended. The device must stop on a stop character and read the next character upon starting. The device should be bi-directional and be capable of accepting tapes of 5, 6, 7, or 8 levels in width without complicated modification. Full servo controlled reel drive is required. Reel sizes up 10 1/2" must be accommodated by this reader.

2.3.2.3 Photoelectric Card Reader

This device will read cards at a rate of 400 to 600 cards per minute. Photoelectric type reading is advocated because of the speed, and to reduce mechanical maintenance. The cards will be read one column at a time so as to keep the number of reading and encoding circuits to a minimum. Handling of the cards passing through the reader will be such that the card deck arrangement after passing through the read station is identical to the arrangement prior to passing through the read station. All signal and information lines will be routed via a plugboard to the I/O register or control source.

2.3.2.4 High Speed Printer

A 500 to 600 line per minute flying wheel printer of 72 columns is required. There will be 64 characters in each column. The printer will accept fan fold paper and shall move the paper via a sprocket mechanism. Spacing control will be determined by plug board wiring. A carriage control tape is required. All signal and information lines will be routed via a plugboard to the I/O Register or control source. The printer shall be capable of both free wheeling and fixed cycle operation.

2.3.2.5 Tape Punch

A chad type tape punching device that operates in the speed range of 40 to 60 characters per second is required. This device will punch tapes of 5, 6, 7 and 8 levels without complicated modifications.

2.3.2.6 Card Punch

A card punch which punches cards at the rate of at least 100 cards per minute is required. A read station will be included in the devices to be used for verification. All signal and information lines will be routed via a plugboard to the I/O register or control source.

2.3.2.7 Other I/O Devices

Other I/O devices that are considered to be optional requirements are:

1. 12 level tape punch
2. 12 level tape reader
3. Slow speed card reader, card punch, card duplicator, card generator (keyboard) combination (such as the IBM 526).

Items 1 and 2 depend upon the policy adopted toward the Robo-tester. Item 3 is recommended for initial use (does not use I/O Register) and for future Control Computer where data handling is of lesser importance.

2.3.3 Instruction Listing for Computer

The various instructions are listed or discussed by types in this section. Figures 21 and 22 illustrate various forms of words that will be used by the control computer with data processing capability.

2.3.3.1 Shift Instructions (Type 0)

+ Shift Accumulator Left	SAL
- Shift Accumulator Right	SAR
+ Circulate Accumulator Left	CAL
+ Shift Lower Arithmetic Register Left	SLL
- Shift Lower Arithmetic Register Right	SLR
+ Circulate Lower Airthmetic Register Left	CLL
+ Circulate Combined Left	CCL
- Pulse Train from Accumulators	PTA
- Pulse Train from Lower Arithmetic Register	PTL
- Pulse Train from Combined	PTL
+ Normalize	NRM

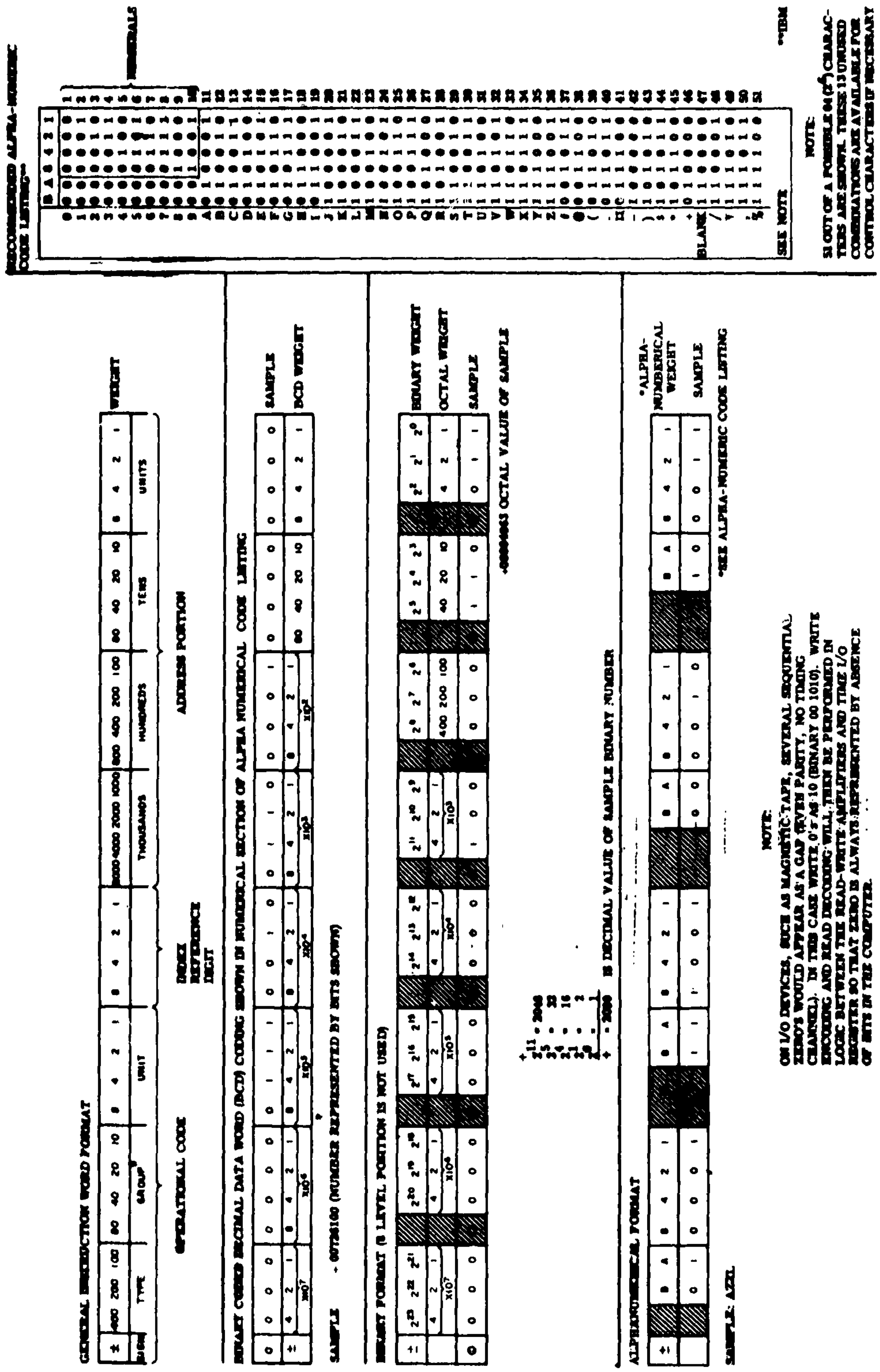


Figure 21. Computer Word Variation Chart

SHIFT INSTRUCTION

0	0 0 0	x x x x	x x x x	0 0 1 0	0 0 0 0	0 0 0 0	0 0 0 0	1 0 0 0	SAMPLE
DIRECTION OF SHIFT	TYPE	GROUP	UNIT	INDEX REF.	NUMBER OF BITS TO BE SHIFTED				

INTERPRETATION OF + 0XX20008:
SHIFT LEFT THE NUMBER OF BITS OBTAINED BY MODIFYING 8 BY INDEX REGISTER #2.

X SIGNIFIES DESIGNERS CHOICE (0-9)

TRANSFER AND MODIFY INDEX INSTRUCTION

1	0	x x x x	0 0 0 1	0 1 0 0	0 0 1 1	1 0 0 0	0 0 0 0	0 1 1 0	SAMPLE

INTERPRETATION OF -XX143806
DECREASE INDEX REGISTER #4 BY (1) AND TAKE THE NEXT INSTRUCTION FROM DRUM ADDRESS 3806.

X SIGNIFIES DESIGNERS CHOICE (0-9)

I/O INSTRUCTION

0	0 0	0 1 0 0	0 0 0 1	0 0 0 0	0 0 0 0	0 1 0 1	0 1 1 1	1 0 0 0	SAMPLE

+44100578

INTERPRETATION
SELECT I/O PAPER TAPE UNIT #1 TO TRANSFER INFORMATION INTO THE COMPUTER MEMORY AS PER THE CONTROL WORD FOUND AT MEMORY ADDRESS 0578. NOTE THAT NO INDEX MODIFICATION IS CALLED OUT BY A O IN THE INDEX REFERENCE DIGIT.

I/O CONTROL WORD REFERENCED BY ABOVE INSTRUCTION

0	0 0	0 0 0	0 0 0 0	0 0 1 1	0 0 0 1	0 0 0 0	0 0 0 0	0 0 0 0

+28031000

INTERPRETATION
TRANSFER 80 COLUMNS BETWEEN DRUM AND I/O SELECTED BY I/O INSTRUCTION IN THE DIRECTION SPECIFIED. THERE ARE 2 COMPUTER CHARACTERS PER COLUMN AND PARITY IS (3)ODD. THE FIRST WORD IS TO BE STORED AT MEMORY ADDRESS 1000.

DIGIT NUMBER		FUNCTION
1	-	SIGN AND OP. CODE TAPE
2	-	GROUP - OP.
3	-	UNIT - OP.
4	-	INDEX REFERENCE DIGIT
5	-	THOUSANDS (ADDRESS)
6	-	HUNDREDS (ADDRESS)
7	-	TENS (ADDRESS)
8	-	UNITS (ADDRESS)

DIGIT #1

\+ INDICATES DIRECTION OF
\- FLOW ADD, SUBTRACT, ETC.
0 SHIFTING
1 ARITHMETIC
2 LOGICAL
3 CONTROL
4 I/O
5 EXTERNAL SWITCHING
6 EXTERNAL ADDRESSING
7 OTHER

DIGIT #2

SPECIFIES GROUP OF I/O's OR GROUPS OF INSTRUCTIONS SUCH AS SHIFT LEFTS.

DIGIT #3

SPECIFIES A SPECIFIC I/O DEVICE OR SPECIFIC INSTRUCTION (SUCH AS SHIFT ACCUMULATOR LEFT). USED AS A NUMERIC (0-9) TO SPECIFY THE AMOUNT TO MODIFY THE INDEX REGISTER REFERRED TO BY.

DIGIT #4

0 - NO REFERENCE
1 - XR #1
2 - XR #2
3 - XR #3
4 - XR #4
5 - XR #5
(6-9) UNUSED

DIGIT #5 - 8

REFERS TO AN ADDRESS IN THE GENERAL CASE.

1. SHIFT INSTRUCTIONS: NO. OF BIT PLACES SHIFTED
2. ON INSTRUCTIONS NOT USING THESE DIGITS THEY MAY BE USED FOR STORAGE OF FOUR DIGIT NUMBERS. AN EXTRA OPERATION IS REQUIRED TO ELIMINATE DIGITS 1 - 4 WHEN THIS NUMBER IS CALLED ON FOR AN OPERATION.
3. ON EXTERNAL SENSE QUERIES THE LINE TO BE SENSED IS REFERENCED BY A NUMBER IN THIS PORTION OF THE WORD.

Figure 22. Computer Word Variation Chart (contd)

2.3.3.2 Arithmetic Instructions (Type 1)

+ Clear and Add	CAD
- Clear and Subtract	CSB
+ Add	ADD
+ Multiply	MPY
- Divide	DIV
Compare Accumulator with Memory	CAM
Convert Binary to BCD	CBC
Convert BCD to Binary	CCB
Convert Binary to Gray	CBG
Round Accumulator	RNA
+ Store Accumulator	SAC
+ Store Lower Register	SLR
+ Store Special Word	STP
- Load Lower Register	LLR
+ Halt	HLT
- Halt and Light Special Instruction	HSI

2.3.3.3 Logical Instructions (Type 2)

AND Memory and Accumulator	AMA
OR Memory and Accumulator	OMA
Invert	INV

2.3.3.4 Control Instructions (Type 3)

Unconditional Transfer	UTR
Transfer on Accumulator Overflow	TAO
Transfer on Lower Overflow	TLF
- Transfer and Decrease Index	TDO-TD9
+ Transfer and Increase Index	T10-T19
Transfer and Place Address in Index	TAX
Compare Index with Address	CXA
Index to Accumulator	XAC
Load Index From Memory	LXM
Load Index from Accumulator	LXA
No Operation	NOP
+ Digital Input Bus to Accumulator	DIA
- Digital Output Bus from Accumulator	DOA
Block Transfer Memory to Loop	BML
Block Transfer Loop to Memory	BLM
+ Trap Transfer	TRT
- Stop Trapping	STR
- Transfer on Minus	TRM
+ Transfer on Plus	TRP
+ Branching Multivibration *	BMN
- Branching Multivibrator Off *	BMF
Branching Multivibrator Check *	BMR

* Signifies one of 10 Branching Multivibrators

2.3.3.5 Input/Output Instructions (Type 4)

The input/output instruction format will be organized as follows:

I. Input/Output Instructions

1. a.	Sign:	+ for data coming in from an I/O - for data going out to an I/O
b.	Type:	This digit will be a 4 to identify it as an I/O type.
2.	Group:	This digit will identify which group of I/O devices is being selected

a. I/O Register (0)
b. Magnetic Tape Devices (1)
c. High Speed Printing Devices (2)
d. Card Devices (3)
e. Paper Tape Devices (4)
f. Manual Entry (5)

3.	Unit:	This digit will identify which device in the group is being selected.
4.	Index Reference:	Identifies which Index Register to use to modify the contents of the address portion of the instruction.
5. 6. 7. 8.	Thousands) Hundreds) Tens) Units	Identifies the address at which the I/O control word is to be found

Transfer of information to and from the drum via the I/O devices connected to internal computer registers requires an Input/Output instruction and a control word. Transfer of information via I/O devices connected to the I/O Register will require an I/O instruction and a control word to load the I/O register and another I/O instruction and a control word to transfer the data to the drum via the internal computer register (or in the reverse order). Notice, however, that if no operation on the data is required, that the second I/O instruction and control word could transfer the same data to another I/O device directly without actually entering the working program drum.

II Input/Output Control Word

The format of the control word will be as follows:

2.3.3.5 (contd)

1. a. Sign:		+ Indicates transmission between drum and I/O device or I/O register - Indicates transmission between an I/O and the I/O register
b. Type)		
2. Group) 3. Unit) 4. Index)		Used for control as required by a specific device. For instance: Number of computer characters per column, number of columns to transfer and parity description.
5. Thousands) 6. Hundreds) 7. Tens) 8. Units)		When control word sign is + these digits identify the memory location that the first data word is to be transmitted to or from. When control word is -, these digits will be used for further information to control the I/O register and the I/O device.

III Other Input/Output Requirements

For control requirements not covered in this control word, I/O instructions will be used. It is not anticipated that the units digit will be required in most cases. For instance, + 430 would select the card reader and - 430 would select the card punch. Also, the highest four numbers of the group digit will not be in use. These operational codes, as well as the address portion, can be used for I/O control and status inquiries.

No further definition of these instructions will be made. Controls required for a specific device, when defined, can be integrated with the other design of the Control Computer. It is anticipated that some of these instructions will be of the "hold" type, and others of the "jump" type, to name two examples.

2.3.3.6 External Switching and External Addressing (Types 5 and 6)

Instructions and control words will be used in much the same manner for these types of instructions as for the Input/Output type.

This will enable certain groups of instructions to reference a control word; other groups will not reference a control word. An instruction to select a test point switch position, for example, would require only the instruction. Notice that the indexing feature will allow a whole series of points to be scanned with only a very few instructions in a sequence; the same sequence being used repeatedly (loop).

2.3.3.6 (contd)

The groups that refer to control words will be indexable again so that the same sequence of instructions can be repeated for various tests. An example of the use of the control word in this case is to contain the programming data required for setting up the dynamic range, function, start source, stop source, start source slope, stop source slope, and decimal point and multiplier for a digitizing component such as a Frequency Counter-Time Interval-Pulse Width Analog to Digital Converter.

The external sense switches (means by which the operator may communicate with the program) will be selected by a number in the address. These will be "jump" type instructions.

2.3.4 Reverse Control Lines

Reverse Control Lines will be provided to enable two way control. Instead of the program sequence, certain programmed inquiries etc. determining what happens, this allowance for other more random control will be provided. It provides a means of obtaining computer services upon demand from an external source. As an example of the manner in which such a feature would be utilized, consider the test system shown where the Control Computer is tied to each test bench. The same approach would also be used if the Control Computer were linked directly to the serial Programmer-Controllers. At some point it is desired to utilize the computer capabilities (Ex. a NO-GO result on a certain test - further testing cannot be done until a computation is performed). A signal would be sent on a Reverse Control line to the Control Computer Plugboard.

2.3.4.1 Single Purpose Reverse Control Line

This would be routed by the plugboard in such a manner that an instruction would be generated during the instruct cycle (artifical TAX-Transfer and Place Address in Index). The normal drum cycle would be inhibited. It would store the present location in an unused index register, and transfer to another part of the stored programs specified by the plugboard to execute the instructions found there. This may be a simple routine or may call for a special routine from magnetic tape to be executed. One of the first instructions in the routine would inhibit further reverse entries. One of the last instructions would release this inhibit. Without the inhibit feature, the machine could conceivably get "lost" in these demand routines if other Reverse Control signals were given before the first was completed. At the end of the demand routine, program control would continue from the address that was stored in the Index Register in the beginning.

2.3.4.1 (contd)

Input gating provisions will be made so that reverse control can be from more than one source. Each gate will occur at a different time in a sequence. This allows only one at a time to be gated in, and sets up a priority if more than one signal arises simultaneously.

2.3.4.2 Multi-Purpose Reverse Control Lines

If a Reverse Control Signal from any one source may demand different routines, the exact routine address to go to would be specified at the source and made available on the Digital Input Lines. The contents of these lines would be gated into the accumulator and thus become available to the Computer. A Reverse Control line for each possible routine from each source would be impractical.

2.4 Automatic Tape Program Preparation

2.4.1 Summary

A method of automatic tape program preparation for resistance, continuity and voltage tests is described. This method can be applied to a Programmer Controller unit of the type specified in this report by including tape punch and limit computation capabilities. This method can also be used directly by the Programmer Computer described. The method of automatic tape program preparation outlined starts with pre-programmed tapes in which test numbers and corresponding test point numbers are consecutively assigned. Type measurement is also pre-programmed. Either an automatic ranging analog to digital voltmeter can be used or a ranging sub program included in the tape which automatically ranges down until a three digit reading occurs. Measured value is used for computing one or more sets of limits based on component tolerance and test experience. Test number, switching commands, type measurement, range and limits are then punched into the final tape. The method is based on measurements taken from a completely operating unit supplemented by technical manual data.

This study has led to the concept of pre-programmed tapes for existing Programmer Controllers as a means of significantly decreasing programming labor. In pre-programming, type measurements as resistance, D.C. voltage, A.C. voltage are pre-assigned to blocks of test numbers. The majority of test point assignments can also be pre-programmed and assigned to these test numbers.

The programmer must then add only limits, ranges and power supply stimulus programming to these existing formats. Adapter cable wiring can be based on the test point type measurement assignments.

2.4.2 General

Automatic tape program preparation is a possible programming technique whereby test data such as limit information is derived from measurements made on a unit known to be in an acceptible operating condition. Checkout of the model unit may be done using manual test methods. In a sense this is a comparison technique whereby data from a working model is extracted to calculate limit information or used directly for a comparison of nominal measured values of the model against those obtained from a unit whose operational status is being determined.

It has already been proven that ATP is feasible, if only to a limited extent. Brooks Research Incorporated, Rochester, New York has developed a unit called "SPACE MARK I" and described it in the November 1959 issue of Electrical Manufacturing published by Conover-Mast Technical Publications Corporation.

The system, presently in use, contains self programming and a leakage and continuity tester. The system has two modes of operation, the Analysis mode, and the verification mode. Its use is primarily in production line testing of wiring harnesses and cables. In the analysis mode the system generates a tape program containing the coordinates of the points which give continuity from a harness or cable known to be good. The tape program can then be used to test subsequent harnesses in the Verification mode by comparing the expected results against the measured results.

The methods used in this system are somewhat simplified and are applied to specific conditions. The measurement value can be one of three values:

1. Equal to or greater than leakage limit
2. Equal to or less than continuity limit
3. Less than leakage limit but greater than the continuity limit

The first two values are specific requirements of the test conditions, i.e., the circuit tested must be continuous or discontinuous. The third value is an erroneous condition which would have to be checked and corrected.

This particular application of automatic tape preparation, while demonstrating the simplest type of automatic program preparation, does point out possibilities in the method. In this case limit determination is greatly simplified and requires no calculation. A value of a few ohms is selected as a continuity limit and some high resistance value is arbitrarily used throughout as a leakage limit. The test criterion is whether a measurement on a unit test equals, is less than or greater than these limits. The method demonstrates a technique for automatic assignment of Programmer Controller test points and corresponding test numbers and automatic tape punching. Despite the test program simplicity, it can be very lengthy for a complex wiring maze and this is a means of reducing the manual programming labor for a tedious checkout task. An objective of this study was to determine feasibility of extending this technique to resistance, voltage and other tests of

2.4.2 (contd)

a typical depot inventory black box or module. It should be emphasized that a prime value of ATE in depot operation for component isolation will be its ability to rapidly and accurately conduct a large number of relatively simple tests. It is estimated that resistance and continuity tests will account for 30% to 40% of module tests and static voltage tests will account for another 25% to 35%. Any reasonable means of simplifying test program preparation for these tests will save a considerable amount of programming time and definitely reduce the possibility of programming errors, with further savings in program debugging time.

2.4.3 Programmer Controller Requirements

To prepare test programs automatically for resistance, continuity and static voltage tests, the following functions would be required of a Programmer Controller such as the AN/GJQ-9:

a. Tape punch capability
b. Limit computation
c. Logic modifications

Figure 23 is a block diagram of a typical Programmer Controller system modified for automatic tape programming. The system shown incorporates loads, stimulus switching, and power supplies for automatic preparation of voltage test programs as well as resistance.

In addition to determining the types of tests which may readily and practically lend themselves to automatic programming and determining what equipment or Programmer Controller operations are needed, an optimum set of operational procedures should be established. One of these procedures is the method of test point selection. This procedure will affect:

a. Quantity of test points or the test point scanner capacity needed.
b. Number of irrelevent, meaningless or redundant tests made.
c. Amount of black box or module analysis that must be performed
d. Configuration and wiring of adapter cables

2.4.4 Test Point Selection

There are several schemes for connecting or scanning test points:

a. Use all test point connections possible on the unit under test and make measurements for all the possible combinations of two lines.

b. Take all signal inputs, outputs, accessible circuit nodal points and supply voltage connections as separate groups of test point connections.

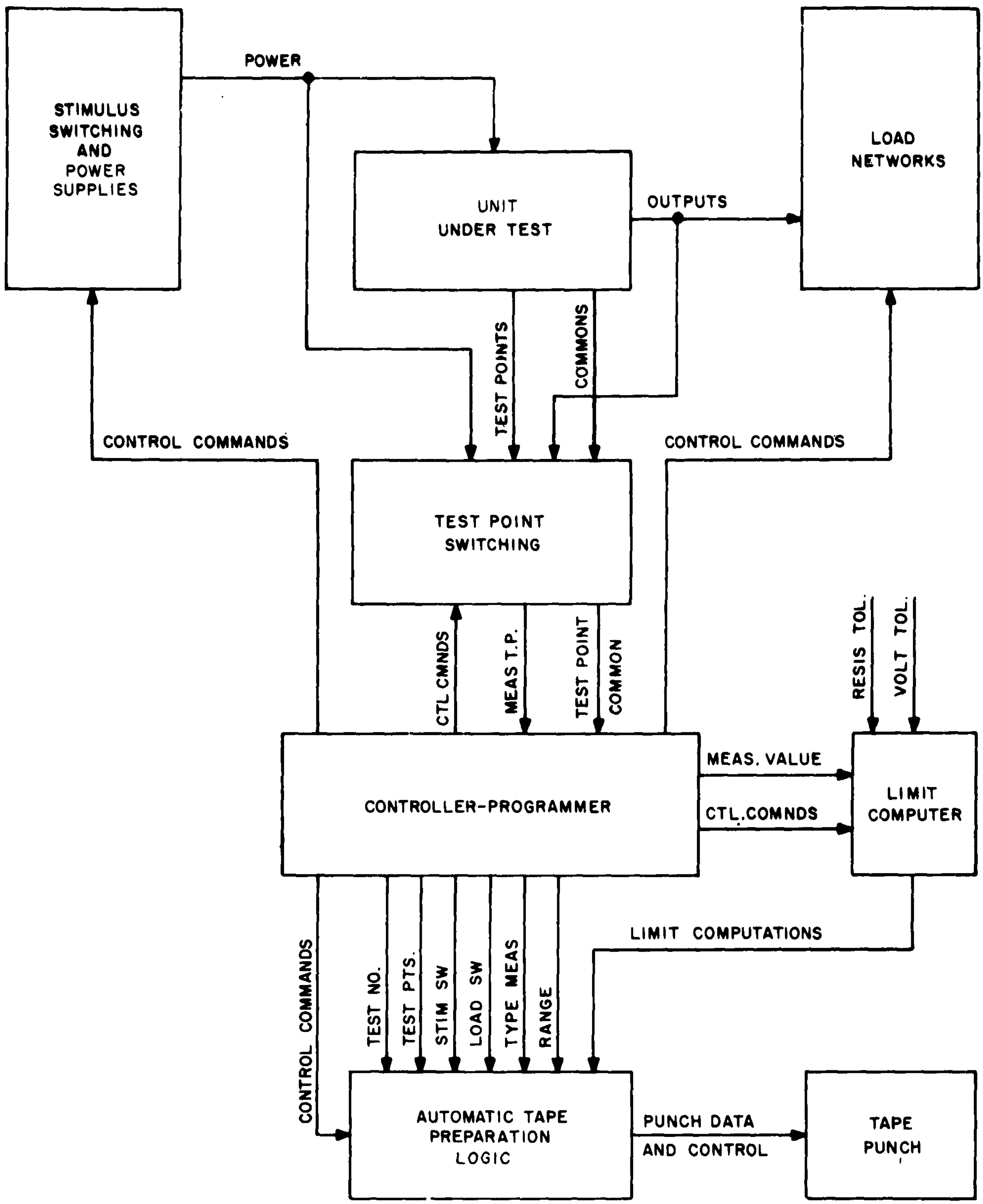


Figure 23. ATE with ATP for Module Tests

2.4.4 (contd)

c. Take known inputs, outputs, accessible circuit points and supply lines and make only those measurements needed.

Of these schemes the first requires the least amount of operator action, while the last requires the most. However, the first scheme makes an excessive number of tests, with considerable redundancy, and ambiguity. The second scheme uses considerably less tests and the third makes only valid measurements. The third also requires the least amount of switching since redundant or unnecessary test points are eliminated. An important consideration in automatic tape programming is to eliminate erroneous or irrelevant measurements. For example, it is erroneous to make a measurement to ground of one side of a floating potential pair, except for an insulation resistance test. Either the voltage across the floating pair should be measured or two measurements to ground made, provided there is a path via another circuit to ground.

Although the last scheme requires the most operator action it is felt that this is warranted since the time spent in initially setting up the equipment for test would be more than justified by comparison to the test time spent checking out other systems and because of minimum requirements for test point relays or scanner capacity. It is recommended then that the circuit of the prospective unit under test be examined to locate all useable test points, preferably those accessible by connector, test point or tube socket adapter. A minimum number of key points which will require clip leads can also be identified. With each test point a common point should be identified. As few common points as possible should be used. Other decisions can be made such as the need for isolation resistors (to tube grid circuits or other high impedance points) between the unit under test circuit and the Programmer Controller.

An arbitrary wiring list for a cable from the unit under test to the P/C can then be made. The only precaution is to route common points to a group of switching separate from the test points which will ultimately be switched to the digital voltmeter-ohmmeter common in the P/C.

2.4.5 Programming Methods

A second procedure which will affect the Programmer Controller equipment and operational capabilities required is the method of programming the Programmer Controller. It is recommended that a special tape program be used for automatic programming. This tape program will utilize a series of test numbers, for example, 1 through 100 and the corresponding test point relay numbers 1 through 100 for resistance tests. A second group of test point relays is needed for the measurement common.

2.4.5 (contd)

Ideally only a single common would be used against which all resistance measurements are made, such as unit under test chassis ground or signal ground. Probably additional commons will be needed for resistance and continuity measurements from circuit components to power supply busses.

The program tape will contain no limit information, this must be derived from the unit under test. Likewise, resistance ranges are not yet known. In this application, an automatic ranging resistance and voltage analog to digital converter would be highly desirable. If this is not available, two ranging techniques are possible. One is to include a subroutine which first commands measurement on the lowest range. If an overload or overrange condition is detected by the A to D converter, it is commanded to switch up one range at a time until a no overrange measurement is made. A preferred subroutine will start with the highest range and proceed to the next lowest range if all significant digits for the range are not present. For example a 3 digit A to D converter will command downward range changes until a 3 digit reading is made.

The test number, test point numbers, function and range information can be transferred unchanged to the output tape. Storage for this information usually exists in present Programmer-Controllers. Gating and timing circuitry must be added, however, to permit readout of this information to the tape punch at the proper time.

The preliminary or accessory tape used for automatic tape preparation will include:

a. Test Number
b. Type Measurement
c. Test Point-Signal Line
d. Test Point-Common Line

Either automatic ranging or a subroutine of ranging commands until a usable measurement reading is made will also be needed. The test data not yet determined are limits.

2.4.6 <u>Determination of Limits</u>

An existing Programmer Controller, with modifications previously described can make measurements of unknown resistances on voltages in the model unit under test as a basis for establishing limits. In the case of resistance measurements, if limits are determined as percentages of measured values, an error is introduced as these measured values are somewhere in the range of ± 5% of center design values, assuming that all resistors are 5% tolerance components. A method of overcoming this

2.4.6 (contd)

difficulty is that the automatic tape programming equipment include a memory of standard RTMA resistance values and a comparison circuit. As a resistance is measured in the unit under test, its value is compared to these standard values. High and low limits are then calculated on the basis of the standard RTMA value closest to the measured resistance value. This procedure could not be applied to measurement of resistances in parallel or series. In this case the actual measured value could be used, which may be in error by as much as 5% or reference made to technical manual schematics for actual combination value calculation. If the component whose resistance is measured is a coil or inductance or a semiconductor diode, actual measured values can be used as limits are somewhat broad in this case.

Whether a measured value, derived RTMA value from a measured value or Technical Manual value is used, the problem of setting limits remains. In using ATE it is recommended that limits be based on deviation from component center design value or nominal value, whether or not the circuit continues to perform. A 5% tolerance component may drift to 15% or 20% of design value without circuit failure, however, the inherent design margin for that circuit has been reduced even if the circuit still operates. The circuit may not then be able to tolerate even a 5% change in some other component value. Alternately, an out of tolerance condition may indicate a trend to failure.

Unless component behavior characteristics are known from life tests or previous study data or unless circuit operation is affected, it is recommended that limits be arbitrarily set at 1.5 to 2 times the tolerance. A 5% resistor would then have limits ± 7 1/2% to ± 10% of center value. A 1% resistor would have limits of ± 2% of center value. To establish tighter limits than these may result in unnecessary removal of good components, to establish broader limits may invite circuit failure due to reduced design margins for the circuits. It is further recommended that the depot initially test to two or possibly three sets of limits in the trial implementation. Although present studies by ARINC on programming the AN/ARC-27 include resistance limit variation, these should be extended to include equipments made by several manufacturers to reflect a great variety of circuit designs and electrical circuit design practice variations between manufacturers.

2.4.7 <u>Use of Pre-Programmed Tapes</u>

A study of automatic tape program preparation has led to the concept of pre-programmed tapes for manual tape program preparation. As a valuable aid in reducing the time and effort of tape program preparation and verification, it is suggested that master tapes can be prepared for a given Programmer Controller which will preassign blocks of test numbers and associated test points for resistance and voltage tests. The test program

2.4.7 (contd)

preparation personnel will be aware of these assignments when specifying adapter cable wiring. For instance, a block of test numbers as test 1 through 99 can be assigned to resistance, 100 to 199 to D.C. voltage tests, and 200 to 299 for A.C. voltage tests. Test numbers, test point group and relays, common point group and type measurement (resistance) can be pre-programmed. By limiting arbitrariness in test point assignment which serves no useful purpose in the majority of tests, a substantial part of the programming effort can be reduced. These master tapes would then be used in a manual tape preparation unit for addition of range, limit, and test point common relay assignments. Likewise, a group of test numbers can be pre-assigned for voltage tests. Further depot experience will produce typical numbers of various types of tests required. For various dynamic tests, no preprogramming is presently recommended due to variety of stimulus programming, measurements, and switching of connections possible.

2.5 Expansion of Economic Factors Resulting from ATE Usage

2.5.1 Summary

To arrive at quantitative results, costs must be derived for manual and ATE methods on a unit basis. Repair costs for ATE were computed from the first study on ATE. Manual costs of repair were taken from available cost figures at the Dayton Air Force Depot. All data was taken from the 15 representative airborne electronic equipments used in the first ATE study. Transportation costs, handling costs, time in the repair cycle and average life of electronic equipments were supplied by the personnel of MDNE at Dayton Air Force Depot.

All data is presented in the Appendix of this report and a summarizing result of the data is presented in this section in Figure 24.

The yearly savings of a manual repair depot which has changed over to ATE are outlined in Figure 25 for increases in MTBF's of 10%, 15% 20% and 25%. The work load of the ATE depot is that outlined in the first ATE study of 6,240 black boxes and 5,592 modules per year. Figure 26 shows a linear increase in savings with an increase in MTBF. When the final results of the ARINC Research Corporation Report on reliability are available, the correct ATE savings due to increased reliability can readily be determined.

After the operation of an ATE Depot is inaugurated, it cannot be assumed that the full benefit of increased reliability is available the first year. Instead, the fall-off of Depot workload will decrease slowly as the more reliable equipments are placed into operation. It is assumed that full benefit of ATE will not be experienced until after 2 to 4 years of operation.

Curve II, III and IV show the results of this section added to Curve I. Each curve shows the accumulating savings resulting from ATE operation with different increases in reliability resulting from ATE. Curve II, III and IV represent an increase in MTBF of tested electronic equipment of 10%, 15% and 20% respectively. When a reliable result for increase of MTBF is available, the accumulated savings of ATE can be extrapolated on the graph of Figure 26.

Since the rate of savings due to the increase in reliability will not immediately follow the advent of ATE installation, the lower portions of Curves II, III and IV are estimated to show a gradually increasing rate of savings for about four years. After four years the savings rate is assumed to be constant.

Another benefit of ATE will be the rapid recording and processing of failure data on electronic components. This should initiate quick action to remedy or replace unreliable parts. The effects of this procedure cannot be tabulated as an ATE savings at this time, however, it can be inferred that a beneficial change will result in the reliability of the electronic equipments serviced.

Fig. 24 Maintenance Costs

Total Repair Cycle Costs per Unit (ATE)

Black Box..$ 274.98

Module.. 146.78

Total Time in Repair Cycle per Unit

Black Box.. 1,377.20 hours

Module.. 995.27 hours

Average Cost of 30 Black Boxes..............................$ 9,608.966

Average Cost of 247 Modules.................................$ 977.802

Average Life of Black Box and Module...................... 7.29 years

Manual Repair Costs per Unit

Black Box..$ 96.220

Module.. 39.937

ATE Repair Costs per Unit

Black Box..$ 74.263

Module.. 19.187

ATE Repair Costs per Unit Minus Parts and Parts Replacement

Black Box..$ 66.503

Module.. 13.980

Fig. 25 Results of ATE Increase in Reliability

% Increase in MTBF	10%	15%	20%	25%
γ	0.0909	0.1304	0.1667	0.200
ATE Savings #1 & #2 (Black Box)	$185,288.69	$277,933.03	$370,577.38	$ 463.221.72
ATE Savings #1 & #2 (Module)	99,713.87	149,570.78	199,427.71	249,284.64
ATE Savings #3 (Black Box)	129,219.59	193,829.39	258,439.18	323,048.98
ATE Savings #3 (Module)	9,064.08	13,596.12	18,128.16	22,660.20
Total ATE Savings for 1 year -	$423,286.23	$634,929.32	$846,572.43	$1,058,215.54

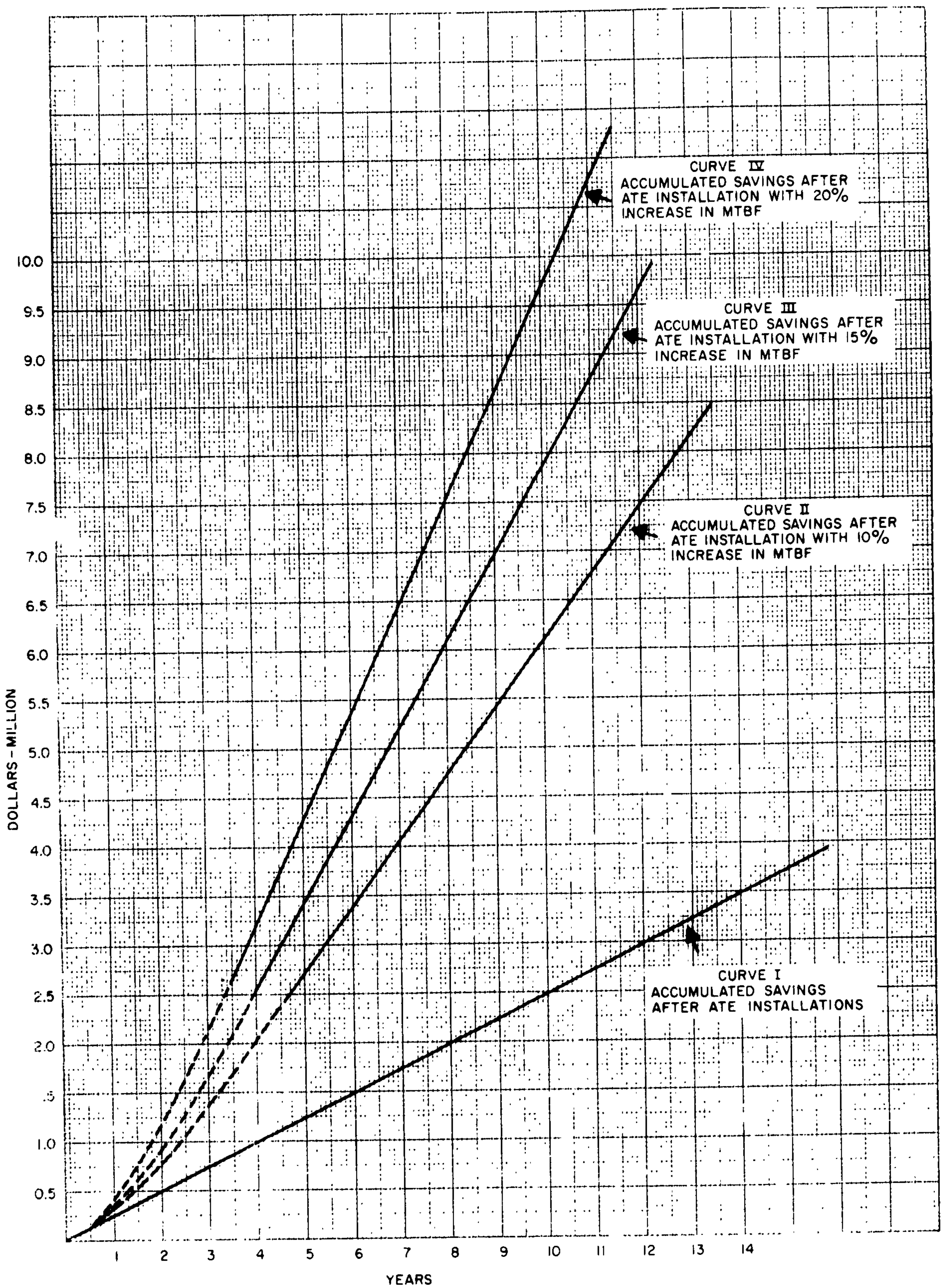


Figure 26. ATE System Accumulated Savings (Revised)

2.5.2 General

The final Engineering Report of the Automatic Test Equipment Study, AF33(604)-28541, indicated that additional saving of the ATE system over a manual system were possible through an increase in reliability of ATE-tested equipments. The report further stated the difficulty of ascertaining this economical advantage at the time of the report writing. This section will be devoted to establishing the quantity of economical benefit resulting from the increased reliability of electronic equipment tested by ATE methods. This section will be general in form with specific results in the summary.

The criteria of reliability used here will be the Mean Time Between Failure (MTBF) figure of operational electronic equipments. It is statistically determined and the basis of this report will be to average results along with the statistical property of MTBF.

The basis for an increased reliability in equipment maintained by ATE methods is a study being conducted by the ARINC Research Corporation. Results of this study are cumulative and a final figure of increased MTBF will not be available for some time. The results of this section will be tabulated for 10%, 15%, 20% and 25% increase in MTBF.

2.5.3 The Effects of ATE on the Maintenance Cycle

If for any reason, a number of electronic equipments begin to give longer service than was previously possible, the maintenance facility repairing the equipments will experience a decreasing workload. A closer look will show other advantages in the repair cycle and in the use of the equipment. It must be assumed that the electronic units are used continuously or are available for continuous use. Also, all faulty units are repaired as rapidly as possible and pressed back into service as required. With these assumptions in mind, increased reliability from ATE will have the following advantageous effects upon the repair cycle:

1. Transportation and handling expense and all expense in locating a faulty component are saved for a more reliable electronic unit.
2. The depreciation cost of the electronic unit while in the maintenance cycle will be retained.
3. The capacity of the maintenance facility will increase with respect to the total maintenance workload.
4. Inventories can be decreased.
5. The ease in recording and storing failure data, while using ATE equipment, may point out defects in components which lead to higher reliability figure

Of these five points, the first three are considered in the following analysis. The fourth point concerns equipment inventories which may be bona

2.5.3 (contd)

fide inventories or "forced" inventories. The "forced" inventories are accumulations of equipments due to the unpredictability of delay in maintenance operations and the unequal time between these operations in the maintenance cycle. These costs are included in point 1. The bona fide inventories are, in main, the inventory on the flight line. The cost of actual storage in this inventory is relatively small and will be ignored for convenience. The last point, involving data accumulation, cannot be ascertained until an ATE facility is in operation for a period of time. Therefore, this point is not included in the analysis.

The repair cycle itself is composed of a number of operations upon an electronic unit to repair the unit and place it back into service. These operations include shipping, handling, locating faulty components, etc., and are illustrated in block form in Figure 27. If an electronic equipment fails, it is removed from the aircraft and checked over in the Armaments and Electronic Shop. If the A&E Shop considers the unit unrepairable by them, the unit will continue on the repair cycle to the Maintenance Depot.

To compute the costs involved in repairing all 15 electronic equipments, and their modules, which were considered in the first ATE Study AF-33(604)-28541, is a task which would absorb the resources of this contract. Therefore, a number of assumptions were made which have a tendency to bring all equipments under either of two headings. The two headings are an average Black Box and an average Module. Costs are figured on this basis for simplifications. Clerical and paper work costs are lumped and estimated in one unit. The simplifying assumptions are enumerated as follows:

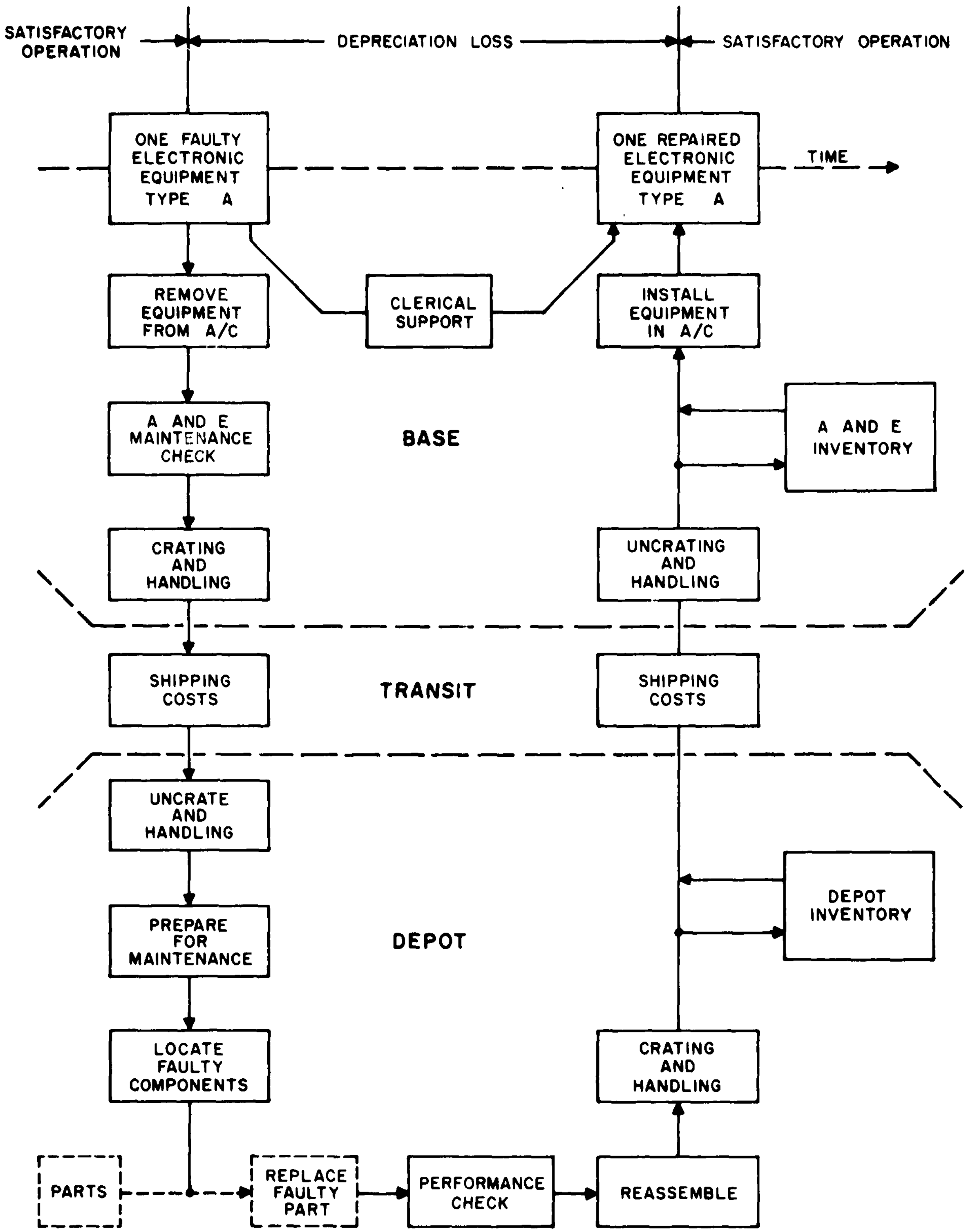


Figure 27. Maintenance Repair Cycle

2.5.3 The Effects of ATE on the Maintenance Cycle (contd)

Simplifying Assumptions:

1. ARINC Research Corporation reliability study is being performed on the AN/ARC-27. It is assumed that any increase in reliability on the AN/ARC-27 resulting from ATE methods is equally applicable to other airborne Electronic Equipments.

2. Averaging of the transportation and handling costs of electronic units was accomplished by considering the RT 220/ARN-21 as an average Black Box and the AM-1579/ARC-58 as an average module.

3. No cost figures are available for an ATE facility. Repair costs were taken from the ATE cost estimates on the first study. (Automatic Test Equipment Study for Dayton Air Force Depot Contract AF-33(604)28541).

4. The cost of replacement parts and the actual installation costs of replacement parts are not considered as a savings of ATE over a manual shop.

5. MTBF figures available on the AN/ARC-27 are for operating time of the AN/ARC-27. The MTBF figures of this study are on a calendar time basis. The relationship for the two is as follows:

$$(\text{MTBF})_c = \frac{\text{Calendar time} \quad (\text{MTBF})_o}{\text{Average operating time}}$$

- where -

$(\text{MTBF})_c$ = Calendar time reliability figure

$(\text{MTBF})_o$ = Operating time reliability figure

6. All electronic test equipment, ATE and manual equipment, were considered to depreciate over ten years. Development costs of ATE also were depreciated over ten years.

7. Overhead costs are considered at 100% of labor costs.

8. ATE shop capacity is taken from the first ATE Study at 6,240 black boxes per year and 5,592 modules per year.

9. Equipment failures which are repaired on the flight line are not considered in this analysis.

10. The value of a Black Box was averaged over 30 electronic units. The cost of an average module was averaged over 247 modules.

2.5.4 General Analysis

For a general analysis, we will consider a large number of electronic equipments consisting of average Black Boxes and average Modules. These equipments are serviced by a number of maintenance depots whose expense in servicing any one unit is the same. The number of failures of the electronic equipments is at a constant rate so that the capacity of each depot is fixed. Now if ATE procedures and equipment are introduced at one of the depots, a breed of electronic equipments with higher reliability will be introduced into the number of operational units. The workload of the ATE depot will fall off if it is assumed this depot derives all the benefit from the increased reliability. The ATE depot will have a certain percentage of its capacity idle, denoted by γ, which will represent the savings introduced by the ATE installation. This percentage capacity which is idle, can be calculated as follows:

$$\gamma = \frac{(MTBF)_2 - (MTBF)_1}{(MTBF)_2}$$

- where -

γ = percentage capacity idle

$(MTBF)_1$ = former failure time

$(MTBF)_2$ = failure time after installation of ATE

The ATE costs savings related to γ is not only the cost of actual repair, but all the transportation and handling cost involved in repairing these units. Thus, the first ATE savings can be calculated as follows:

$$\text{ATE Savings \#1} = \gamma \times \left(\frac{\text{Maint Repair Cycle Costs}}{\text{Unit}}\right) \times \text{Depot Capacity}$$

If it is assumed that the percentage capacity idle is utilized by drawing off from the capacity of the manual repair facilities, a second saving results from the application of ATE.

$$\text{ATE Savings \#2} = \gamma \times \left(\frac{\text{Manual Repair Costs - ATE Repair Costs}}{\text{Unit}}\right) \times \text{Depot Capacity}$$

However, this action introduces a new set of higher reliability equipments and ATE Saving #1 must be applied to them. This in turn introduces more idle maintenance facilities and the process extended ad infinitum. The combination of ATE Saving #1 and #2 will then be:

ATE Savings #1 and #2

$$= \left(\frac{\text{Maint Repair Cycle Costs}}{\text{Unit}} + \frac{\text{Manual Repair Costs - ATE Repair Costs}}{\text{Unit}}\right)$$

$$(\gamma + \gamma^2 + \gamma^3 + \ldots)\ (\text{Depot Capacity})$$

2.5.4 General Analysis (contd)

ATE Savings #1 and #2

$$= \left(\frac{\text{Maint Repair Cycle Costs}}{\text{Unit}} + \frac{\text{Manual Repair Costs - ATE Repair Costs}}{\text{Unit}}\right)$$

$$\frac{\gamma}{1-\gamma}\ (\text{Depot Capacity})$$

A third savings resulting from an ATE facility is the extended utilization of the electronic equipments with higher reliability. The time which the faulty electronic equipment spends in the repair cycle cannot be considered as part of the useful life of the equipment. However, if any equipment continues to stay in service due to a higher reliability, this additional time in service represents a benefit from the higher reliability. Then a third savings in ATE is:

$$\text{ATE Savings \#3} = \text{Time in Repair Cycle X } \frac{\text{Avg Equipment Cost}}{\text{Avg Equipment Life}} \left(\frac{\gamma}{1-\gamma}\right) \text{X Depot Capacity}$$

The total savings due to the reliability increase of electronic equipment serviced by ATE procedures is the sum of ATE savings #1 and #2 and ATE Saving #3. This does not include the direct labor savings estimated in the Final Engineering Report of the first ATE Study AF 33(604)-28541.

2.6 SUPPORT CONSIDERATIONS FOR AUTOMATION

2.6.1 Summary

The installation and operation of the General Purpose Automatic Test System at DAAFD will, in general, require the same support functions as the Depot Repair Shop. The MRS (Materiel Repair System) now in use at DAAFD was investigated to determine compatibility with the General Purpose Automatic Test System. Emphasis was placed on those departments having closest contact with the Depot Repair Shop as these departments will have the closest contact with the General Purpose Automatic Test System. The effect of automation on the departments supporting the MRS will be secondary in nature with the primary departmental functions remaining unchanged. Modifications of methods and techniques used to accomplish their primary functions are recommended for Production Control, Quality Control and Industrial Engineering. Automation will not greatly affect other departmental functions concerned with supporting the MRS. To insure a minimum of integration problems when the changeover occurs and to guarantee maximum utilization of ATE, the training of personnel in new techniques and methods must be accomplished simultaneously with the development of the ATE.

2.6.2 Industrial Engineering

Preparation of work standards (time standards) for equipments to be serviced will be a function of Industrial Engineering. Work standards for modules requiring servicing must also be determined.

Section 2.6.4.3 describes a requirement for generation of time data during operation of the General Purpose Automatic Test System. This process records the time involved for ATE set-up, defective unit hook-up and tear-down, and actual test time at the test bench. This information is generated primarily for utilization by Industrial Engineering to determine work standards and time sharing capabilities of the General Purpose Automatic Test System.

Initial work standards and time sharing factors can be determined from preliminary tests after development of test programs. Subsequent workloads of black boxes/modules will generate more information which then can be used to modify the existing standards.

The General Purpose Automatic Test System facility requirements will be determined during the ATE development phase. Industrial Engineering must determine what depot facility modifications are performed prior to arrival of the ATE.

One factor requiring attention, not only in the installation phase but in the operating phase as well, is the primary AC power supply. The maximum requirement may be determined during the ATE development stage but since most building blocks will have single phase power inputs as opposed to a 3 phase main supply, a phase balancing procedure will be required. It is suggested that this be done during or as a by-product of scheduling when required building block type and quantities are available.

2.6.3 Quality Control

Quality Control's responsibility for maximizing reliability of serviced end items will not be changed. Instead of relying on manual test equipment, system-mockups and a sampling procedure, end item quality will be a function of automatic test programs and the accuracy of the automatic test equipment. Once the test programs are written and proved, automatic test equipment accuracy is the prime factor determining reliability of end items. In conjunction with Production Control, Quality Control can maximize the ATE Reliability-Confidence Factor by self test programs (self contained and external standards), proper calibration adjustments, and periodic preventive maintenance procedures.

Results of tests and calibration adjustments will be recorded, and personnel from Quality Control can monitor these records to verify end item reliability. Responsibility for the mechanical inspections of end items will not change.

When problem areas are detected, present procedures will apply and appropriate departments must cooperate to solve these problems.

2.6.4 Production Control

The implementation of the General Purpose Automatic Test System will require a change in techniques used to obtain information and data for the Production Control function. All information such as bits and pieces usage, work standards, etc., will be based on automatic test procedures instead of manual procedures. The bits and pieces requirements will be somewhat increased due to the greater number of components checked and there will be an additional requirement for spare modules. It should again be emphasized that training of personnel to operate the test area should be done prior to installation of the General Purpose Automatic Test System.

Scheduling, Pre-Production planning, and test data generation are also function of Production Control and are covered in following discussions.

2.6.4.1 Scheduling

Delivering a schedule for end item servicing is a function of Production Control, and in addition to promoting a smooth flow of serviced end items provides the following information necessary for operation of the General Purpose Automatic Test System.

1. Estimated bits and pieces requirements for the schedule period.

2. Estimated modules required for substitution during the schedule period.

3. Building block requirements for the schedule period.

Proper scheduling techniques will minimize the total building block requirements and minimize the changing of building blocks from one set up to the following set up.

The process of scheduling requires addition, subtraction, multiplication, division and storage of intermediate results and is suited to the use of a computer. With the exception of workloads and priority information, the data required can be stored on cards for use by the computer. These cards can be periodically revised as newer and more accurate information becomes available.

The following actual or estimated information must be available for each end item to be serviced.

1. Service time per end item

2. Time sharing factors for Programmer Controller and building blocks

3. Modules and bits and pieces usage factors

4. Total building block requirements

5. Workload

6. Priority assigned to end items

The following general information must be available:

1. Spare module and bits and pieces assets

2. Total building block assets

3. Status of building blocks in use at start of new schedule period

End items must be sorted into groups by building block requirements. If necessary, a group may be divided into sub-groups if the number of test benches is greater than the number of groups. The groups can be formed on the basis of the following sorting:

1. Programmable transfer oscillators

2. Programmable oscillators

3. Programmable pulse generators

4. Programmable power supplies

5. Combinations of the above

To forsee and correct shortages of spares the module and bits and pieces usage should be calculated (module or bits and pieces usage factor x workload) and compared to spare assets (actual spares + projected additions). If spares are not available, end item servicing can be scheduled when spares become available. In the absence of actual data and experience the following assumptions will be made to simplify the scheduling procedure.

1. An effective working day of 5.6 hours is assumed for GPATS and test benches to allow for a 70% efficiency factor.

2. In general, final performance tests for an end item will be done after all defective module isolation tests are completed for that particuluar end item.

3. Final performance tests require the same building blocks as defective module isolation tests.

4. An over-run of 1 day is assumed for any test bench for computing available building blocks. This prevents an over-run at one bench from delaying changeovers at another bench.

5. An ATE changeover will idle the bench concerned for .75 hours and will idle the Programmer-Controller and all other benches associated with it for .37 hours.

6. An idle time is assumed when the time sharing factor of all benches associated with a Programmer-Controller is greater than 100%.

The scheduling process involves using data described by the following questions. The data can be computed using the information for each end item and the general information previously described.

1. Where are building blocks located at any given time?

2. What quantity of building blocks are required to service the end items?

3. What building blocks were used for previous bench set-up?

4. Assuming schedule is followed, what building blocks are in stock or storage?

5. What are the building block assets if it is assumed any bench can have an over-run of one day?

6. What are the new assets after new requirements for any bench have been subtracted and building blocks released from previous setups are added?

By using a computer to sort data on end items, to choose next end item to be serviced on basis of building block requirements, time sharing factors, etc., and keeping a running account of all data required to answer the six previous questions, a schedule may be derived.

2.6.4.2 Pre-production Planning

A pre-production workload estimate can be made using the same basic format as the scheduling process. From an overall list of end items the pre-production estimate process must select the end item and quantities of end items that can be serviced.

Assuming that test programs are available for the end items the workload estimate requires finding answers to:

1. Are the types and quantities of building blocks available to service the end item?

2. Can the stated workload be done?

3. If the stated workload cannot be done, what quantity can be done?

The scheduling format keeps a running account of time spent at the bench, time left at the bench and Building Blocks available. By comparing available Building Blocks to required Building Blocks, the first question may be answered. The second question may be answered by comparing the required service time (end item time x workload + ATE set-up) with time left at a bench or benches. The third question may be answered in a manner similar to the second by solving for workload when available time is known.

2.6.4.3 Data Output From Test Area

Production Control must increase their activity in the generation of data concerning test results, failure and repair information, and time information. This data should be generated by equipment/personnel of the test area for use by other areas of the depot. There will be some manual insertion of information onto data forms. Identical data formats and forms would be utilized for final performance, defective module and defective component levels of depot maintenance.

A description of information required and final use of each type of information follows:

1. Test Results - This print out of end item tests, ATE self tests, and calibration tests will provide a permanent record to aid Quality Control in verification of end item quality or in an analysis of problems or methods of improving quality of end items.

2. Failure and Repair Information - This information will be tagged to the defective item after initial testing and remain on the defective item until indicated repairs are completed. It must contain the class stock number of the defective module, serial number or code number of the defective module, information correlating the no-go test number or numbers with properly identified defective components (class, stock number, circuit nomenclature), and out of tolerance readout. Duplicate cards will be required for Materiel Performance, Data Services, obtaining spare components from stock, earned materiel records and other functions. The significance of this data is further shown in Figure 28 (Module Repair Cycles) and in Section 2.6.5.

3. Time Information - To derive an adequate and valid schedule, pre-production schedule or workload estimate, Production Control must have valid black-box/module actual hook-up and tear-down time, test time, operator participation time, and time sharing factors (requires additional computation). These figures will be processed and periodically modified by Industrial Engineering. Time information must be fed to Industrial Engineering from the test area. To relieve the test bench operator of tedious time-keeping and to insure the validity of data, instruments similar to time clocks will be associated with the test bench and commanded by the Programmer-Controller. These instruments will generate the required time information for several segments of the test sequence.

The time or operating sequence of the time devices might be as follows:

1. Operator manually commands a time print and reset to zero before setting up required building blocks.

2. Programmer-Controller commands timer readout and reset to zero as it starts into the test sequence.

3. Programmer-Controller commands timer readout and reset to zero as it releases control to Control Computer (this step and following step will be eliminated if the Control Computer is not required for the particular end item being tested).

4. Control Computer commands timer readout and reset to zero as it completes tests or releases control to Programmer-Controller.

5. Programmer-Controller commands timer readout and reset to zero as it ends test sequence (unless Control Computer has finished tests without releasing control).

6. Programmer-Controller commands readout and reset to zero at start of test sequence on new end item.

It will be necessary to produce a code to identify the various printouts. If step 1 selected a code letter "A" to be printed with the time print at the 2nd step and the 2nd step selected a code letter "B" etc., then each time readout would be accompanied by an identifying code. The time from one step to another is now identified and may be classified as follows:

Time Step to Step	Codes
1 - 2	A
2 - 3	B
3 - 4	C
4 - 5	B
5 - 6	D

Where

A = Time required to set up required building blocks and obtain special cables, fixtures, etc., and hook-up first end item.

Sum of all B's = test time + substitution and adjustment time.

C = Control Computer usage timer.

D = Tear down and set up time required to switch equipments of same type.

After the above information has been collected for a number of end items of the same type, an average figure may be calculated and used as required time or time standards for scheduling purposes.

2.6.5 Module Repair Cycle

An automatic test system to service the workload as presented in the Final Engineering Report on Automatic Test Equipment Study for DAAFD (Contract No. AF 33(604)-28541) involves a quantity of defective modules which necessitate a repair cycle (instead of repair by test area personnel) for effective operation. A suggested flow diagram for the testing and repair of defective modules is shown in Figure 28.

The simultaneous arrival of the defective modules and the spare parts required to repair the modules at the repair area is expected to present problems. All efforts should be expended toward this simultaneous arrival, as a repair area back-up of either defective modules awaiting spares or spares without the defective modules is undesirable. In general, the needed spares should be immediately available from the spare parts storage area with little dependency on outside or other sources.

The repairable (defective) modules are sent to the repairable modules storage from the field if they are treated as a separate end item and/or from the black-box test area where defective modules are located and removed. The modules that have been tested and repaired during the previous cycle and are awaiting retest are also stored in this area.

Upon notification from Production Control (according to schedule), the repairable modules are moved into the test area and tested. After determination of defective components, modules are tagged with necessary identification data and sent to a storage area for a definite constant time. Identical information starts through the cycle for obtaining the required spare parts. Storage of defective modules immediately after testing is to compensate for the time to locate spare parts, when available, and transport them to the repair area. A two-day period is presented, but is subject to change. If the spare item is not available at the depot, the defective module is removed to an adjacent storage area during this two-day period, and remains there until notification of arrival at the depot of the required spares. Notification of shortage of spare parts and arrival of spare parts is also given to Production Control for scheduling purposes.

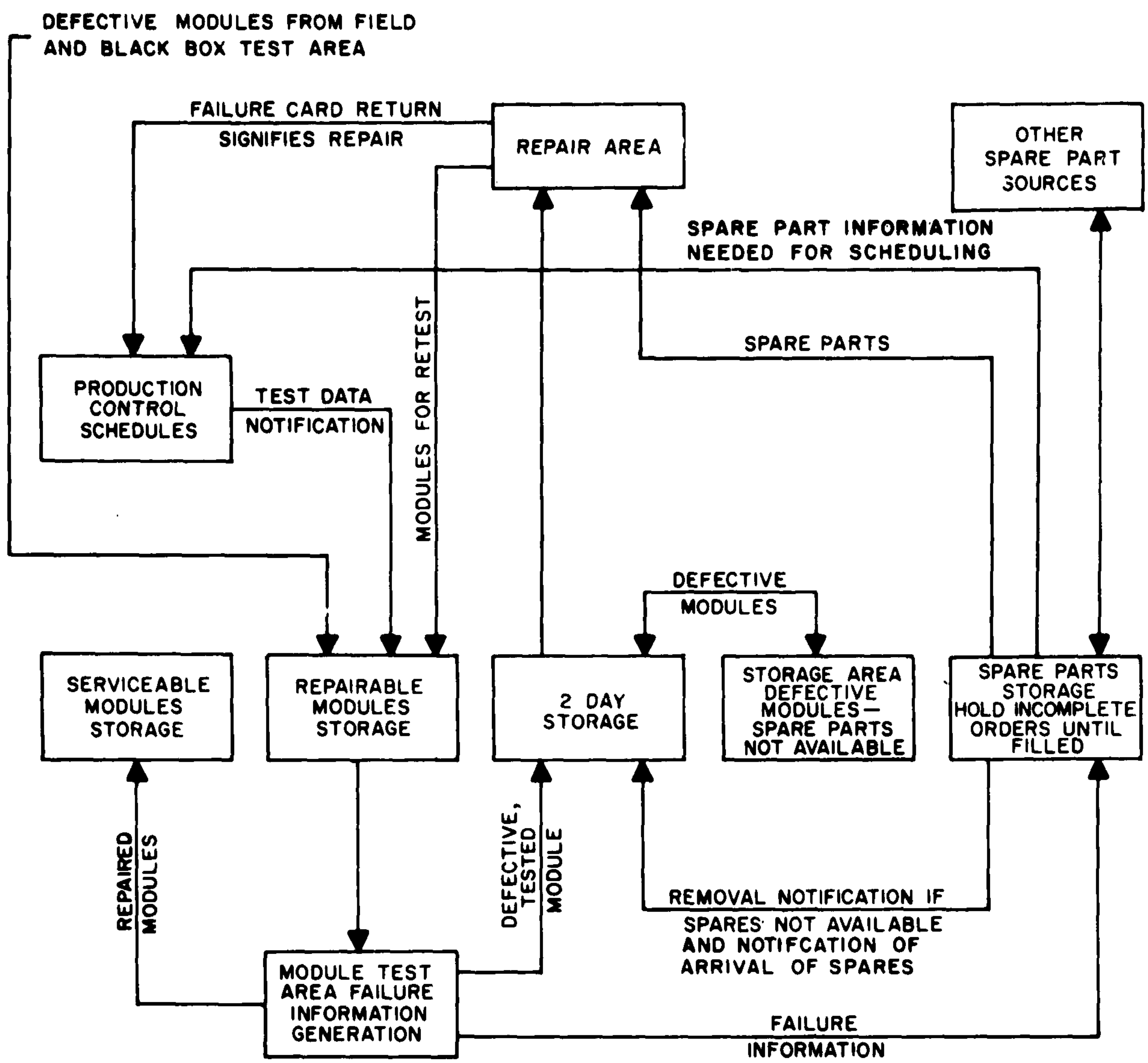


Figure 28. Module Repair Cycle

Plug in components (mainly tubes) can be stored in the automatic test area and substituted into defective modules immediately so retest can be accomplished without removal from the test area.

The defective modules and spare parts arrive at the repair area, are matched, modules are repaired, and sent to the repairable module storage area to await retest as previously stated. Failure cards are routed to Production Control to confirm repair of modules.

The repaired modules will be retested and after acceptance sent to the serviceable module storage area. These modules may be shipped directly to the field and/or be used for substitution into defective black boxes.

Two slight variations might occur in the cycle. A good module might be erroneously shipped from the field or black box test area, in which case the module will go directly from the test area to the serviceable module storage area. The other will occur when the repaired module will still be defective due to faulty or insufficient test programming or damage during repair. This module will be redirected through the repair cycle.

2.7 Equipment Survey for Determining Building Block Requirements

2.7.1 Summary

The automatic test system determined by the first study was applied to 21 systems at Dayton during the present extension. The automatic test system required four additional building blocks to check out the AN/APN-136 and the AN/ALQ-16. The Oscillator from 40 - 400 MC and Oscillator from 8.4 - 10.4 KMC previously specified were modified to include additional requirements. The final Automatic Test System determined by the first study and the extension has the capability to check out a total of 36 airborne electronic systems which are presently being repaired at DAAFD and future equipment to be repaired by depot.

The final automatic test system will consist of 44 stimulus generator, response monitor and load building blocks to perform defective module and defective component isolation of various airborne electronic systems. The automatic test system will be able to check out different systems by using a test tape and a group of building blocks assembled in a test area with a limited number of accessories to perform fault isolation of a particular unit to be tested.

2.7.2 General

The Final Engineering Report on USAF Contract AF 33(604)32036 is in part to show the results of applying the automatic test system as defined by the previous study to a select group of new and varied airborne electronic systems. The purpose was to confirm the versatility and the capabilities of the Automatic test system to perform testing when applied to electronic system for both the present and the predictable future.

2.7.3 Airborne Electronic Equipment Surveyed

The various airborne electronic systems in the B-58, F101B, F105 and other aircraft were investigated to determine the building blocks required by the automatic test system to perform defective module isolation and defective component isolation of a particular equipment. The types of equipment surveyed were communications, IFF, Countermeasures, radar and navigational equipment to be checked out by the automatic test system.

The communications and navigational equipment surveyed were the ARC-70, ARC-57, ARC-74, ARR-61, AIC-20, ARN-62, ARN-61, ARA-48 and ARN-50.

The radar, ECM and IFF equipment surveyed were APN-136, APN-135, ALR-12, ALQ-16, Chaff Dispenser, APX-37, APX-26 B, APX-27 B, APX-34, APX-46, APX-47 and APX-48. Of these, the last four equipments were surveyed only to determine if new building blocks were required and their specific test requirements are not listed in this section.

2.7.4 Additional Building Block Requirements

The airborne electronic systems that required additional building blocks were the Position Indicator radar beacon set AN/APN-136 and the countermeasures set AN/ALQ-16. The AN/APN-136 required three new building blocks, the Oscillator 12.4-18.0 KMC, Peak Power Meter (12.4 - 18.0 KMC), and Spectrum Analyzer 12.4 - 18.0 KMC. The AN/ALQ-16 required one new building block which was the Oscillator 2.60 - 3.95 KMC.

2.7.5 Additional Requirements to Existing Building Blocks

The building blocks described in the previous study required specification changes to increase the capabilities of the automatic test system to check out the AN/ARR-61 and AN/ALQ-16. The oscillator from 40-400 MC required frequency modulation capabilities in order to check out the Radio Receiver Set AN/ARR-61. The X-Band signal generator was extended from 10.4 MC to 12.4 KMC to perform automatic check out of the countermeasures set AN/ALQ-16. The peak power meter specification was modified to include measurements to 18 KMC as this device uses separate waveguide thermistor mounts for each band.

2.7.6 Revised Building Block List

The building block list as presented in the first Final Engineering Report on Automatic Test Equipment Study has been revised. Several items formerly considered as building blocks have been grouped into the accessory category. The items formerly classed as building blocks which have now been categorized as accessories are as follows:

1. X-band noise generator

2. Precision calibrated waveguide attenuator
3. Standard gain horn
4. Wavemeter (absorption type)
5. Coincidence detector
6. Thermocouple voltmeter

The X-band noise generator specification called out in the Final Engineering Report under Contract AF 33(604)-28541 actually called for noise generation over a spectrum broader than X-band. Because these generators are wave guide mounted devices for fixed noise power output levels, automation is not practical and the generator is now termed an accessory.

The other items are used infrequently and their operation also cannot be automated for practical purposes. It is recommended that existing depot equipment continue to be used for these applications, at least during the initial ATE implementation. As ATE application expands, further definition of requirements for these accessories may eventually return then to a building block status.

In the analysis of feasible building block designs, it became apparent that the programmable oscillator 0.1 cps - 30 KC specifications should be revised to delete the requirement for generation of sawtooth, trapezoid and triangular waveshapes. Instead, a separate Function Generator building block is recommended which operates in conjunction with the programmable pulse generator. This capability is not required as often as 0.1 cps - 30 KC sine wave generation (five applications in component and module isolation for the 15 systems originally studied) and classification as a separate building block will also have economic advantages.

It should be noted also that some building block listings have been resolved into two or more physical units for design advantages and convenience and economy of usage. This is true of the Programmable AC supply primary voltage building block which is now specified as separate single phase and three phase regulators. The spectrum analyzer building block has also been resolved into units covering discrete bands.

2.7.7 Black Box Versus Building Blocks for Defective Module Isolation

The charts of figures 29, 30, and 31 on pages 95, 96, and 97 showing black box versus building blocks required for defective module isolation, are taken from the three monthly progress letters of the automatic test equipment study extension. The charts show the number of times a particular building block is required to check out a black box with ATE. The charts are used to determine total test equipment requirements for defective module isolation of a particular black box.

The charts showing black boxes versus building block for defective module isolation are for the following equipments:

Figure 29	AN/APX-37
	AN/ARC-70
	AN/ARN-62
	AN/ARN-61
	AN/AIC-20
	AN/APX-27B
	AN/APX-26B
	PP-1851/ASQ-37

MODULE ISOLATION	MODULE ISOLATION							AN/APX-27B			AN/APX-26B				
	RT-437/APX-37	RT-435/ARC-70	PP-1851/ASQ-37	RT-436/ARN-62	R-842/ARN-61	CV-621/ARN-62	AN/AIC-26	POWER SUPPLY (002 UNIT)	TRANSPONDER AMP. SYN. (033 UNIT)	TRANSPONDER AMP. CONV. (106 UNIT)	INTERROGATOR AMP. SYN (014 UNIT)	INTERROGATOR AMP. CONVERTER (006 UNIT)			
0. PROGRAMMER - CONTROLLER	X	X	X	X	X	X	X	X	X	X	X	X			
1. PROGRAMMABLE OSCILLATOR 0.1 CPS - 30KC		X		X	X	X	X								
2. PROGRAMMABLE OSCILLATOR 30KC - 40MC				X	X				X	X	X	X			
3. PROGRAMMABLE OSCILLATOR 40MC - 400MC		X		X	X	X									
4. PROGRAMMABLE OSCILLATOR 950MC - 1250MC	X			X											
5. PROGRAMMABLE OSCILLATOR 8.5KMC - 10KMC										X		X			
6. 100MC CUT-OFF VIDEO AMPLIFIER															
7. PULSE GENERATOR	2		X	X		X			X	X	X	X			
8. DELAY GENERATOR	X	X	X	X	X	X	X	X	X	X	X	X			
9. 10MC CUT-OFF VIDEO AMPLIFIER															
10. PROGRAMMABLE TRANSFER OSCILLATOR 5MC - 175MC		X								X		X			
11. PROGRAMMABLE TRANSFER OSCILLATOR 155MC - 605MC		X													
12. PROGRAMMABLE TRANSFER OSCILLATOR 475MC - 1525MC															
13. PROGRAMMABLE TRANSFER OSCILLATOR 1.475KMC - 10.5KMC															
14. PULSE GENERATOR															
15.															
16. OSCILLATOR 2.60 - 3.95 KMC															
17. OSCILLATOR 12.4 - 18.0 KMC															
18. SYNCHRO TRANSMITTER															
19. PROGRAMMABLE RESISTIVE LOAD			X					X							
20. PROGRAMMABLE INDUCTIVE LOAD			X												
21. PROGRAMMABLE CAPACITIVE LOAD															
22. PROGRAMMABLE IMPEDANCE METER							X								
23. PROGRAMMABLE MULTIMETER	X	X	X	X	X	X		X	X	X	X	X			
24. TIME INTERVAL AND FREQUENCY METER	X	X	X	X	X	X			X	X	X	X			
25. POWER METER AND REFLECTOMETER		X													
26. PEAK POWER METER (12.4 - 18.0 KMC)															
27. WAVEFORM ANALYZER	X		X	X		X			X	X	X	X			
28. SPECTRUM ANALYZER															
29. PEAK POWER METER	X			X											
30. STATIC PRESSURE GENERATOR															
31. SPECTRUM ANALYZER 12.4 - 18.0 KMC						X									
32.															
33. PHASE METER															
34. AMPLITUDE MODULATION DETECTOR		X													
35 PROGRAMMABLE POWER SUPPLY 0.1 - 35VDC (2.5A)		X													
36. PROGRAMMABLE POWER SUPPLY 22 - 32VDC (20A)	X	X	X	X	X	X	X		X	X	X	X			
37 PROGRAMMABLE POWER SUPPLY 30 - 500VDC	2	X		X	X	X			2	3	3	3			
38. PROGRAMMABLE POWER SUPPLY 500 - 6000VDC										X		X			
39. PROGRAMMABLE AC SUPPLY 400 CPS PHASE REFERENCED						X									
40. PROGRAMMABLE AC SUPPLY 400 CPS		X						X	X	X	X	X			
41 PROGRAMMABLE AC SUPPLY 6.3V						X									
42. PROGRAMMABLE AC SUPPLY 30 CPS															
43. PROGRAMMABLE AC PRIMARY VOLTAGE			X	X	X	X									

Figure 29. Black Box vs Building Blocks for Module Isolation #1

MODULE ISOLATION

				CHAFF DISPENSER		AN/ARC-74				AN/ARC-57												AN/APN-135					
		R-753/ARN-50	RT-545/APN-136	PERFORMANCE CHECK - CHAFF DISP.	MODULE ISOLATION - CHAFF DISP. CONTROL	RF MODULE AN/ARC74	MODULATOR AN/ARC74	AMPLIFIER AN/ARC74	POWER SUPPLY AN/ARC74	C-1944/ARC57, C-1943/ARC57, CHASSIS 500 AN-1490	C-1943/ARC57 MONITOR CONTROL	C-1944/ARC57 FREQUENCY CONTROL	CHASSIS 500 AN-1490/ARC57	CHASSIS 550 AN-1490/ARC57	CHASSIS 500 AN-1490/ARC57	CHASSIS 650 AN-1490/ARC57	MODULATOR HD-283/ARC57	GUARD RECEIVER R762/ARC57	IF & AF AN-1439/ARC57	PERFORMANCE CHECK AN/ALR-12	MODULE ISOLATION AN/ALR-12	HI VOLTAGE & RF AN/APN135	IF AMPLIFIER AN/APN135	PULSE WIDTH DISC. AN/APN135	CODER BOARD AN/APN135	AURAL MONT. ETC. AN/APN135	ELEC. CONTROL AMP. AN/APN135
0	PROGRAMMER-CONTROLLER	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
1	OSCILLATOR 0.1CPS-30KC	X					X	X									X		X								
2	OSCILLATOR 30KC-40MC							X						X					X								
3	OSCILLATOR 40MC-400MC	X				X						X		X	X	2		X					X				
4	OSCILLATOR 950MC-1250MC																			X	X						
5	OSCILLATOR 8.5KMC-10KMC																			X	X	X					
6	100MC CUT-OFF VIDEO AMP																					X					
7	PULSE GENERATOR		X	X	X						X									X	X	X		X	X	X	X
8	DELAY GENERATOR	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
9	10MC CUT-OFF VIDEO AMP					X		X										X	X								
10	TRANSFER OSC 5MC-175MC					X		X		X								X	X								
11	TRANSFER OSC 165-605MC																										
12	TRANSFER OSC 475-1525MC																										
13	TRANSFER OSC 1.475-10.5KMC																					X					
14	NOISE GENERATOR																										
15																											
16	OSCILLATOR 2.60-3.95 KMC																										
17	OSCILLATOR 12.4-18.0 KMC		X																								
18	SYNCHRO TRANSMITTER																										
19	RESISTIVE LOAD	X	X	X	X	X	X	X	X						X		X	X	X			X				X	X
20	INDUCTIVE LOAD																										
21	CAPACITIVE LOAD																										
22	IMPEDANCE METER																										
23	MULTIMETER	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
24	TIME INTERVAL & FREQ. METER	X	X	X	X	X		X		X				X				X	X		X	X		X	X	X	
25	POWER METER & REFLECTOMETER					X									X							X					
26	PEAK POWER METER (12.4-18.0 KMC)		X																								
27	WAVEFORM ANALYZER		X	X	X															X	X	X				X	
28	SPECTRUM ANALYZER																										
29	PEAK POWER METER																					X					
30	STATIC PRESSURE GENERATOR																										
31	SPECTRUM ANALYZER 12.4-18.0 KMC		X																		X				X		
32																											
33	PHASE METER	X																									
34	AMPLITUDE MODULATION DET.															X		X									
35	POWER SUPPLY 0.1-3.5VDC (2.5A)					X	X	X			X																
36	POWER SUPPLY 22-32VDC (20A)	X		X	X	X	X	X	X	X	X	X		X	X	X	X			X	X	X					
37	POWER SUPPLY 30-500VDC	2		X	X	2	X			2	X	X		2	3	X	4	X	X	2	2						
38	POWER SUPPLY 500-6000VDC																										
39	AC SUPPLY 400CPS PHASE REF.	X		X	X																						
40	AC SUPPLY 400CPS	X		X	X																						
41	AC SUPPLY 6.3V					X				X	X	X		X	X	X	X	X	X								
42	AC SUPPLY 30CPS																										
43	AC PRIMARY VOLTAGE		X															X		X	X	X	X	X	X	X	X
	APPROX. NO. OF TESTS			124	90	18	6	18	13	44	8	6		5	8	30	7	6	14	20		3	20	12	5	12	5

Figure 30. Black Box vs Building Blocks for Module Isolation #2

TABLE I MODULE ISOLATION

FORM B	R-583 RA-11/ABR-11	CY-381 DA-8/ABR-01	LR-T1 RECEIVER LOCK OSC/ALQ-10	LR-T1 RECEIVER LOCK OSC/ALQ-10	RE-T1 RECEIVER LOCK OSC/ALQ-10	LR-T1 POWER AMP/ALQ-10	LR-T1 POWER AMP/ALQ-10	RE-T1 POWER AMP/ALQ-10
0 PROGRAMMER-CONTROLLER	X	X	X	X	X	X	X	X
1 OSCILLATOR 0.1 CPS-30MC	X		X	X	X			
2 OSCILLATOR 30MC-400MC								
3 OSCILLATOR 400MC-4000MC	X							
4 OSCILLATOR 900MC-1200MC								
5 OSCILLATOR 8.2KMC-12.4KMC			X				X	
6 100MC CUT-OFF VIDEO AMP								
7 PULSE GENERATOR		X	X	X	X	X	X	X
8 DELAY GENERATOR	X	X	X	X	X	X	X	X
9 10MC CUT-OFF VIDEO AMP								
10 TRANSFER OSC 5MC-175MC	X							
11 TRANSFER OSC 165-600MC	X							
12 TRANSFER OSC 475-1525MC								
13 TRANSFER OSC 1.475-10.5KMC								
14 NOISE GENERATOR								
15 X-BAND NOISE GENERATOR								
16 OSCILLATOR 2.60-3.95KMC				X	X	X		X
17 OSCILLATOR 12.4-18.0KMC								
18 SYNCHRO TRANSMITTER								
19 RESISTIVE LOAD	X							
20 INDUCTIVE LOAD								
21 CAPACITIVE LOAD								
22 IMPEDANCE METER								
23 MULTIMETER	X	X	X	X	X	X	X	X
24 TIME INTERVAL & FREQUENCY METER	X	X	X	X	X			
25 POWER METER & REFLECTOMETER								
26 PEAK POWER METER (12.4-18.0KMC)								
27 WAVEFORM ANALYZER	X	X	X	X	X	X	X	X
28 SPECTRUM ANALYZER								
29 PEAK POWER METER			X	X	X	X	X	X
30 STATIC PRESSURE GENERATOR								
31 SPECTRUM ANALYZER 12.4-18.0KMC								
32								
33 PHASE METER								
34 AMPLITUDE MODULATION DET								
35 POWER SUPPLY 0.1-35 VDC (2.5a)						X	X	X
36 POWER SUPPLY 22-32 VDC (30a)	X		2	2	2			
37 POWER SUPPLY 30-300 VDC	X		3	3	3	3	3	3
38 POWER SUPPLY 300-600 VDC								
39 AC SUPPLY 400 CPS PHASE REF								
40 AC SUPPLY 400 CPS			X	X	X			
41 AC SUPPLY 6.3V								
42 AC SUPPLY 30 CPS								
43 AC PRIMARY VOLTAGE	X	X	X	X	X	X	X	X

Black Box vs Building Blocks for Module Isolation #3A

DRIVER AMPLIFIERS AN/ALQ-10

FORM B	MODULE ISOLATION		COMPONENT ISOLATION			MODULE ISOLATION	COMPONENT ISOLATION			MODULE ISOLATION	COMPONENT ISOLATION			
	DRIVER AMPLITUDE LRT-1 AN/ALQ-10		LR-T1 POWER SUPPLY AN/ALQ-10	ELECTRON TUBE LR-T1 AN/ALQ-10	LR-T1 CHASSIS AN/ALQ-10	DRIVER AMP RE-T1 AN/ALQ-10	RE-T1 POWER SUPPLY AN/ALQ-10	ELECTRON TUBE RE-T1 AN/ALQ-10	RE-T1 CHASSIS AN/ALQ-10	DRIVER AMP. LH-T1 AN/ALQ-10	LH-T1 POWER SUPPLY AN/ALQ-10	LH-T1 VOLTAGE REGULATOR AN/ALQ-10	LH-T1 ELECTRON TUBE AN/ALQ-10	LH-T1 CHASSIS AN/ALQ-10
0 PROGRAMMER-CONTROLLER	X		X	X	X	X	X	X	X	X	X	X	X	X
1 OSCILLATOR 0.1 CPS-30MC			X				X							
2 OSCILLATOR 30MC-400MC														
3 OSCILLATOR 400MC-4000MC														
4 OSCILLATOR 900MC-1200MC														
5 OSCILLATOR 8.2KMC-12.4KMC	X			X	X	X		X	X	X			X	X
6 100 MC CUT-OFF VIDEO AMP.														
7 PULSE GENERATOR	X					X				X				
8 DELAY GENERATOR	X		X	X	X	X	X	X	X	X	X	X	X	X
9 10 MC CUT-OFF VIDEO AMP.														
10 TRANSFER OSC 5MC-175MC														
11 TRANSFER OSC 165-600MC														
12 TRANSFER OSC 475-1525MC														
13 TRANSFER OSC 1.475-10.5KMC														
14 NOISE GENERATOR														
15 X-BAND NOISE GENERATOR														
16 OSCILLATOR 2.60-3.95KMC	X			X		X		X		X			X	
17 OSCILLATOR 12.4-18.0KMC														
18 SYNCHRO TRANSMITTER														
19 RESISTIVE LOAD			X				X				X	X		
20 INDUCTIVE LOAD														
21 CAPACITIVE LOAD														
22 IMPEDANCE METER			X				X				X	X		
23 MULTIMETER	X		X		X	X	X		X	X	X	X		X
24 TIME INTERVAL & FREQUENCY METER														
25 POWER METER & REFLECTOMETER	X			X	X	X		X	X	X			X	X
26 PEAK POWER METER (12.4-18.0KMC)														
27 WAVEFORM ANALYZER				USE TUBE PW. SUPPLY				USE TUBE PW. SUPPLY					USE TUBE PW. SUPPLY	
28 SPECTRUM ANALYZER														
29 PEAK POWER METER	X					X				X				
30 STATIC PRESSURE GENERATOR														
31 SPECTRUM ANALYZER 12.4-18.0KMC														
32														
33 PHASE METER														
34 AMPLITUDE MODULATION DET														
35 POWER SUPPLY 0.1-3.5 VDC (2.5a)														
36 POWER SUPPLY 22-32 VDC (30a)	X		X	X		X	X	X		X		X	X	
37 POWER SUPPLY 30-300 VDC	X		X	X		X	X	X						
38 POWER SUPPLY 300-600 VDC	X					X								
39 AC SUPPLY 400 CPS PHASE REF														
40 AC SUPPLY 400 CPS														
41 AC SUPPLY 6.3V														
42 AC SUPPLY 30 CPS														
43 AC PRIMARY VOLTAGE	X		X	X		X	X	X		X	X	X	X	
44 SOLENOID POWER SUPPLY	X		X	X		X	X	X		X			X	
APPROXIMATE NUMBER OF TESTS	46	1	133	4	20	46	133	46		14	[illegible]	[illegible]	8	36

TABLE I
5

Module vs Building Blocks for Component Isolation #3A

Figure 31.

2.7.7 (contd)

Figure 30

AN/ARC-74
AN/ARC-57
AN/ARN-50
AN/APN-136
AN/APN-135
AN/ALQ-12
Chaff Dispenser

Figure 31

AN/ALQ-16
AN/ARR-61

2.7.8 Module Versus Building Blocks for Defective Component Isolation

The charts of figure 31, 32, 33, and 34 on pages 97 , 99 , 100, and 101 showing module versus building blocks required was taken from the three monthly progress leters of this study. The charts show the number of times a building block was required for component isolation of a particular module. The charts are used to determine total test equipment requirements for defective component isolation.

The charts showing module versus building blocks required for defective component isolation cover the following equipment.

Figure 32

AS-909/ARN-48
AN/ARC-70
AN/APX-37
AN/ARN-62
AN/ARN-61
AN/APX-27B
AN/APX-26B
PP-1851/ASQ-37 and AN/AIC-20

Figure 33

AN/ARN-50
AN/ALQ-12
AN/ARC-74
AN/ARC-57
AN/APN-135
AN/APN-136
Chaff Dispenser

MODULE TO COMPONENT ISOLATION

Building blocks (column numbers):

0 PROGRAMMER - CONTROLLER
1 PROGRAMMABLE OSCILLATOR 0.1CPS - 30KC
2 PROGRAMMABLE OSCILLATOR 30KC - 40MC
3 PROGRAMMABLE OSCILLATOR 40MC - 400MC
4 PROGRAMMABLE OSCILLATOR 950MC - 1250MC
5 PROGRAMMABLE OSCILLATOR 8.5KMC - 10KMC
6 100MC CUT-OFF VIDEO AMPLIFIER
7 PULSE GENERATOR
8 DELAY GENERATOR
9 10MC CUT-OFF VIDEO AMPLIFIER
10 PROGRAMMABLE TRANSFER OSCILLATOR 5MC - 175MC
11 PROGRAMMABLE TRANSFER OSCILLATOR 16MC - 605MC
12 PROGRAMMABLE TRANSFER OSCILLATOR 475MC - 1525MC
13 PROGRAMMABLE TRANSFER OSCILLATOR 1.475KMC - 10.5KMC
14 NOISE GENERATOR
15
16 OSCILLATOR 2.60-3.95 KMC
17 OSCILLATOR 12.4-18.0 KMC
18 SYNCHRO TRANSMITTER
19 PROGRAMMABLE RESISTIVE LOAD
20 PROGRAMMABLE INDUCTIVE LOAD
21 PROGRAMMABLE CAPACITIVE LOAD
22 PROGRAMMABLE IMPEDANCE METER
23 PROGRAMMABLE MULTIMETER
24 TIME INTERVAL AND FREQUENCY METER
25 POWER METER AND REFLECTOMETER
26 PEAK POWER METER (12.4-18.0 KMC)
27 WAVEFORM ANALYZER
28 SPECTRUM ANALYZER
29 PEAK POWER METER
30 STATIC PRESSURE GENERATOR
31 SPECTRUM ANALYZER 12.4-18.0 KMC
32
33 PHASE METER
34 AMPLITUDE MODULATION DETECTOR
35 PROGRAMMABLE POWER SUPPLY 0.1 - 35VDC (2.5A)
36 PROGRAMMABLE POWER SUPPLY 22 - 32VDC (20A)
37 PROGRAMMABLE POWER SUPPLY 30 - 500VDC
38 PROGRAMMABLE POWER SUPPLY 500 - 6000VDC
39 PROGRAMMABLE AC SUPPLY 400CPS PHASE REFERENCED
40 PROGRAMMABLE AC SUPPLY 400CPS
41 PROGRAMMABLE AC SUPPLY 6.3V
42 PROGRAMMABLE AC SUPPLY 30CPS
43 PROGRAMMABLE AC PRIMARY VOLTAGE

43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Module	Unit	Equipment
		X				X	X													X	X														X						X	X	X	1.85MC IF AMP		RT-435/ARC-70
		X				X	X	X												X				X											X							X	X	AUDIO AMP		
							X														X														X								X	MECHANICAL DRIVE		
		X				X	X												X		X											X	X		X								X	SPECTRUM GENERATOR		
							X														X														X								X	RELAY UNIT		
		X				2		2											X																X							X	X	MODULATOR		
		X				2																													X					X			X	POWER AMP		
		X				X																													X					2	X		X	MAIN REC & PREAMP		
		X				X	X												X		X														X						2		X	20-30MC IF AMP		
		X				X		X											X		X	X		X									X		X					X	X	X	X	GUARD REC		
		X				X													X		X												X		X								X	OSCILLATOR UNIT		
		X					X														X														X								X	MAIN CHASSIS		
		X				X													X	X	X														X				X				X	PRESELECTOR & REC CRYSTAL		RT-437/APX-37
		X				X										X				X	X														X	X				X			X	IF AMP		
		X				3										X				X	X														X	X							X	VIDEO AMP & CONTROL CK'T		
		X				2	X	X								X			X	X	X														X	2							X	CODER - DECODER		
		X			2	2										X			X	X	X														X	X							X	MODULATOR		
		X												X						X	X														X	X							X	TRANSMITTER OSC.		
																				X	X			X											X	X							X	POWER SUPPLY		
							X													X	X														X	X							X	CASE ASSEMBLY		
							X					X								X	X														X	X							X	FRAME ASSEMBLY		
							X									X			X	X	X														X	X							X	PP-1825/ASQ-37		
																				X	X			X											X								X	280/130 MODULE		PP-1851/ASQ-37
			X				X													X	X			X											X								X	BIAS MODULE		
							X													X	X			X											X								X	130 RECTIFIER MODULE		
						X		X												X	X			X											X								X	140 REGULATOR MODULE		
			X				X													X	X														X								X	RELAY ASSEMBLY		
			X				X													X	X		X												X	X							X	AM-1779/ARA-48		
							X									X				X	X														X								X	RE-339/ARA-48		
						X		X												X	X														X								X	CHASSIS		
							X													X	X														X								X	430 RECTIFIER MODULE		
																				X	X			X											X	X				X		X	X	ANTENNA AS909/ARA-48		
		X				X														X	X														X					X			X	OSC. A1		RT-436/ARN-62
							X													X															X								X	FREQUENCY SELECTOR CONTROL A-12		
						X	X													X															X				X	X			X	MIXER QUAD. A-2		
						X														X	X														X					X			X	DOUBLER AMPLIFIER A-3		
						X														X	X														X				X	X			X	AMPLIFIER TRIPLE A-4		
		X				X														X	X														X				X		X	X	X	IF AMPLIFIER A-11		
		X				X						X								X	X														X	X							X	MODULATOR A-1		
		X					X	X											X	X	X														X							X	X	X	DISTANCE DECODER A-9		CV-621/ARN-62
		X					X	X								X				X	X														X	X					X	X	X	INTERROGATION PULSE GEN. A-12		
		X					X	X								X				X	X														X	X					X	X	X	TIME DISCRIMINATOR A-10		
		X	X				X									X				X	X														X						X	X	X	DISTANCE SERVO AMP. A-11		
		X				X		X								X				X	X														X	X					X	X	X	BEARING DECODER A-8		
		X				X		X								X				X	X														X	X					X	X	X	COARSE BEARING DETECTOR A-7		
		X				X		X								X				X	X														X	X					X	X	X	FINE BEARING DETECTOR A-6		
		X				X														X	X														X								X	CHASSIS		
		X				X														X	X														X						X	X	X	BEARING SERVO A-5		
		X				X													X	X															X							X	X	BEARING COUPLER A-1		
X	X		X			X													X	X															X							X	X	DISTANCE DECODER A-2		
						X	X	X												X	X														X								X	RELAY MODULE A-4		
							X													X	X														X							X	X	PHASE DETECTOR A-3		
																				X															X								X	RADIO SET CONTROL C-1856/ARN-62		
X	X					X	X													X															X					X			X	GLIDE SLOPE RF A-1		R-842/ARN-61
X	X					X	X												X	X															X								X	GLIDE SLOPE OSC A-3		
X	X					X	X													X															X						X	X	X	GLIDE SLOPE IF AMP A-2		
X	X					X	X													X															X							X	X	GLIDE SLOPE AF MODULE A-4		
X	X					X	X													X															X					X			X	LOCALIZER RF MODULE A-5		
X	X					X	X												X	X															X								X	LOCALIZER OSC. A-7		
X						X	X													X															X							X	X	LOCALIZER AF MODULE A-8		
X						X	X													X															X					X		X	X	MARKER BEACON RF & IF A-9		
X						X	X													X															X							X	X	MARK BEACON LIGHT & LOCALIZER SQUELCH A-10		
X						X	X													X															X							X	X	AUDIO MIXER A-11		
X						X	X													X															X						X	X	X	LOCALIZER IF MODULE A-6		
							X														X														X							X	X	AM-1748		AN/AIC-20
							X														X														X							X	X	AM-1798		
							X													X															X							X	X	C-2322/AIC-20		
			X																	X	X			X											X								X	437686 SUBASSEMBLY	POWER SUPPLY (002 UNIT)	AN/APX-27B
			X																	X	X			X											X								X	437687 SUBASSEMBLY		
			X																	X	X			X											X								X	437688 SUBASSEMBLY		
			X																	X	X			X											X								X	FRAME		
			X			2										X				X	X														X	X							X	OSCILLATOR CONTROL AMP (005 UNIT)		
			X			3	X							X		X				X	X														X	X							X	RADIO TRANSMITTER (011 UNIT)		
			X													X			X	X	X														X	X							X	FRAME	(033 UNIT)	
		X				2										X			X	X	X														X	X					X		X	432384 SUBASSEMBLY		
			X		X	2													X	X															X	X		X					X	430877-1 SUBASSEMBLY	TRANSPONDER AMP CONVERTER (106 UNIT)	
		X				X										X				X	X														X	X					X		X	437725 SUBASSEMBLY		
			X																	X	X														X								X	FRAME		
			X			3	X					X				X			X	X	X														X	X							X	INTERROGATOR ELECTRICAL SYN (003 UNIT)		AN/APX-26B
			X			2										X				X	X														X	X							X	OSCILLATOR CONTROL AMP (005 UNIT)		
									X											X																							X	INTERROGATOR - TRANSPONDER CONTROL (008 UNIT)		
			X			3	X							X		X	X			X	X														X	X							X	RADIO TRANSMITTER (011 UNIT)		
			X			3	X					X				X			X	X	X														X	X							X	FRAME	INTEROGATOR AMP SYNC (014)	
		X				2										X				X	X														X	X					X		X	432384 SUBASSEMBLY		

Figure 32. Module vs Building Blocks for Component Isolation #1

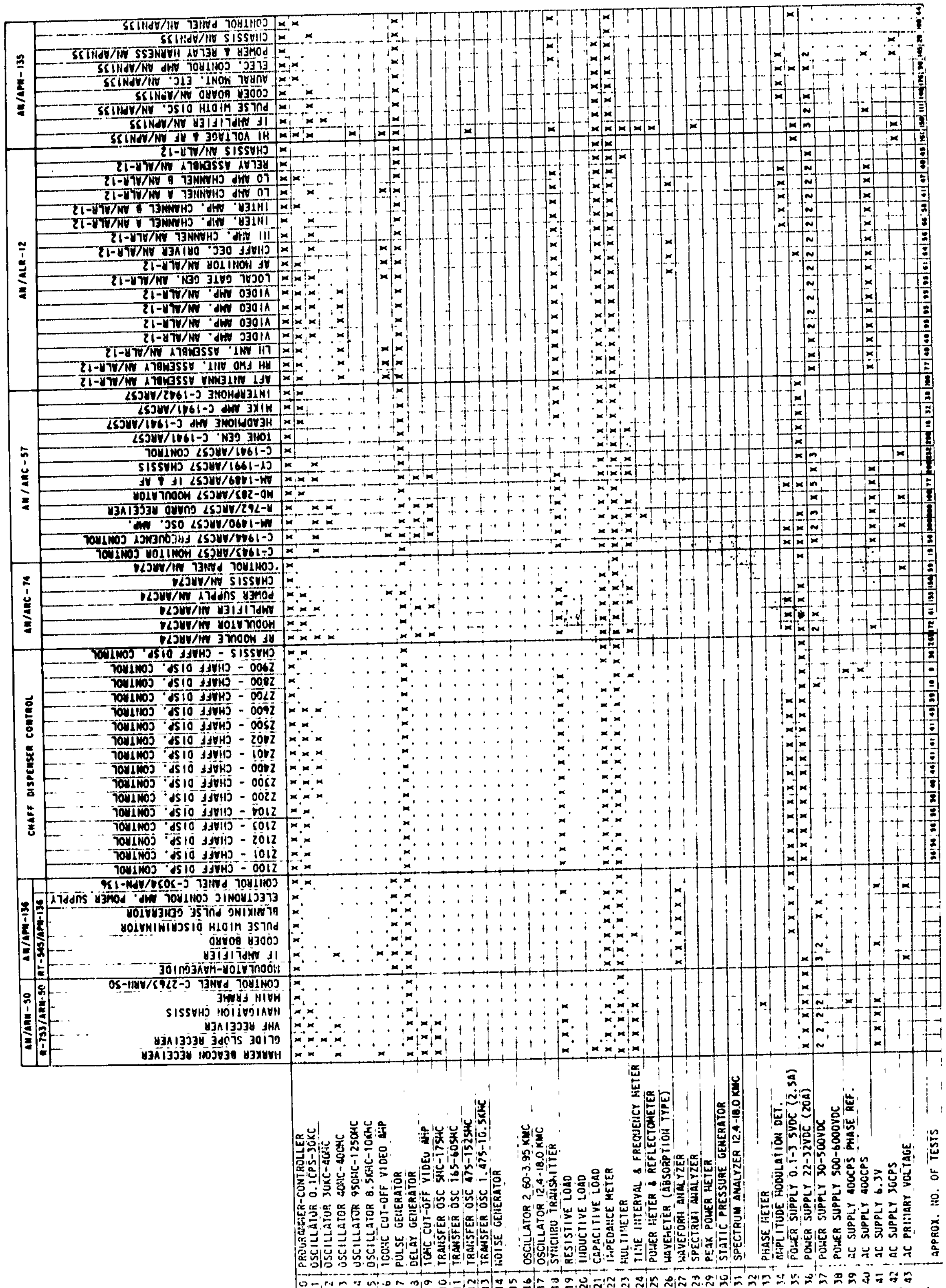


Figure 33. Module vs Building Block for Component Isolation #2

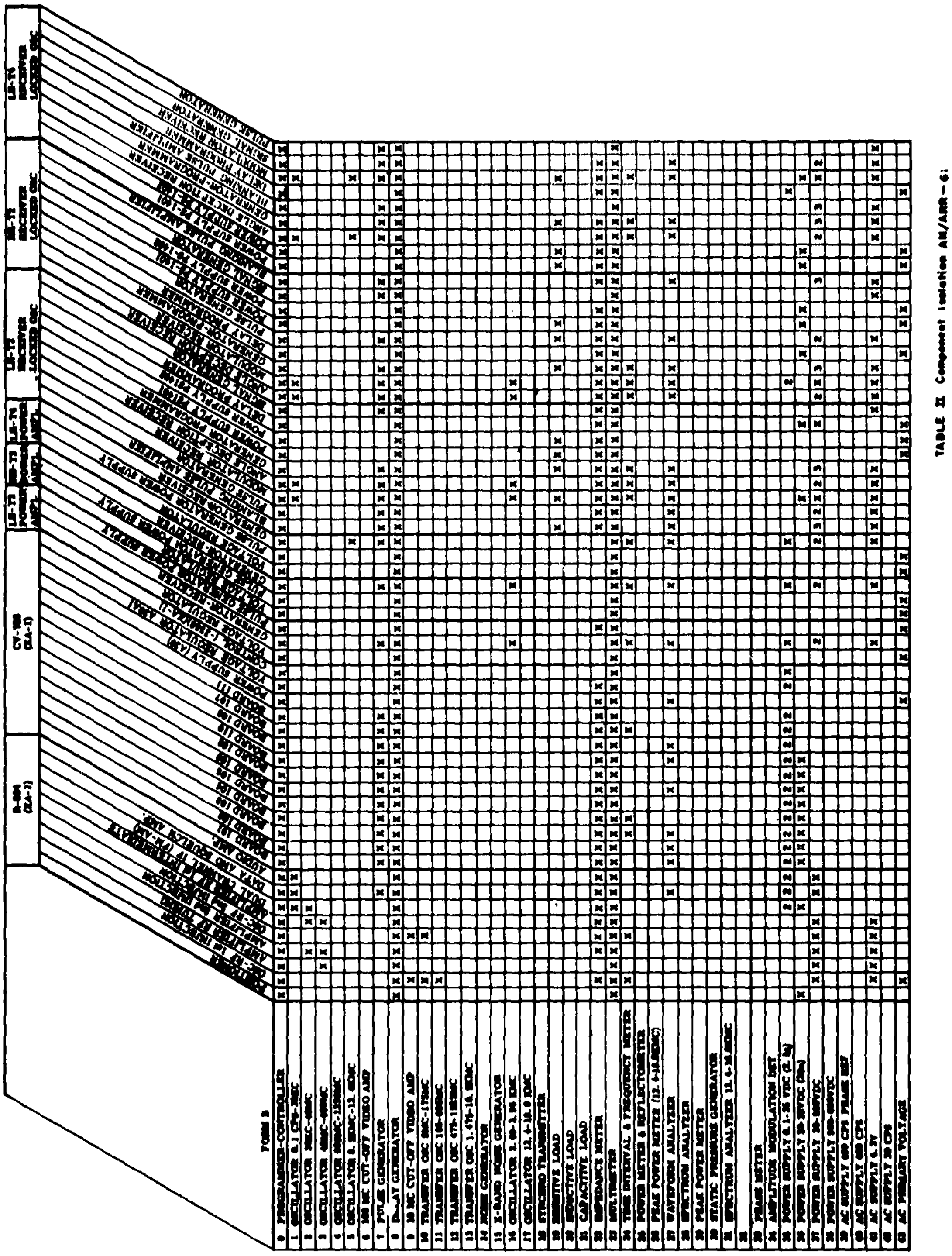


Figure 34. Module vs Building Blocks for Component Isolation #3B

2.7.8 (contd)

Figure 31

AN/ALQ-16

Figure 34

AN/ARR-61
AN/ALQ-16

2.7.9 Additional Accessory Requirements

Additional Accessories are required to check out the AN/ARR-61, AN/ALQ-16 and AN/APN-136 with the automatic test system. The Radio Set AN/ARR-61 requires a special coder unit to operate in conjunction with the pulse generator. The countermeasure Set AN/ALQ-16 requires a special solenoid power supply to check out the various TWT in the system. The Position Indicating Radar Beacon Set AN/APN-136 requires a Ku band wave-meter (absorption type) to measure frequency of the radar pulse.

2.7.10 Building Blocks Versus Their Frequency of Occurrence for Defective Module Isolation

The graph of Figure 35 shows comparative duty of 42 building blocks employed in defective module isolation for the equipment surveyed in the extension and the equipment investigated in the first Automatic Test Equipment Study. The ordinate of this graph shows the frequency a particular building block was required in 79 defective module isolation tests. The ordinate is in percent points where 100 percent will represent the use of a building in all 79 module isolation tests.

The most frequently used building blocks are the programmer-controller, programmable multimeter, delay generator, and the Power Supply from 0.1 - 35 VDC. Among the stimulus generators all ranges of programmable oscillators are used with the low frequency being predominant. The frequency and time interval meter, and waveform analyzer are used approximately for 50 percent of the defective module isolation tests.

2.7.11 Building Blocks Versus Their Frequency of Occurrence for Defective Component Isolation

The graph of figure 36 shows comparative duty of each of 42 building blocks which are employed in defective module component isolation. This graph combines the information from the first automatic test equipment study for DAAFD and the extension. The ordinate of the graph is expressed in the percent of modules using a particular item for component isolation. The total number of modules investigated was 477, representing 100 percent on the ordinate of this graph.

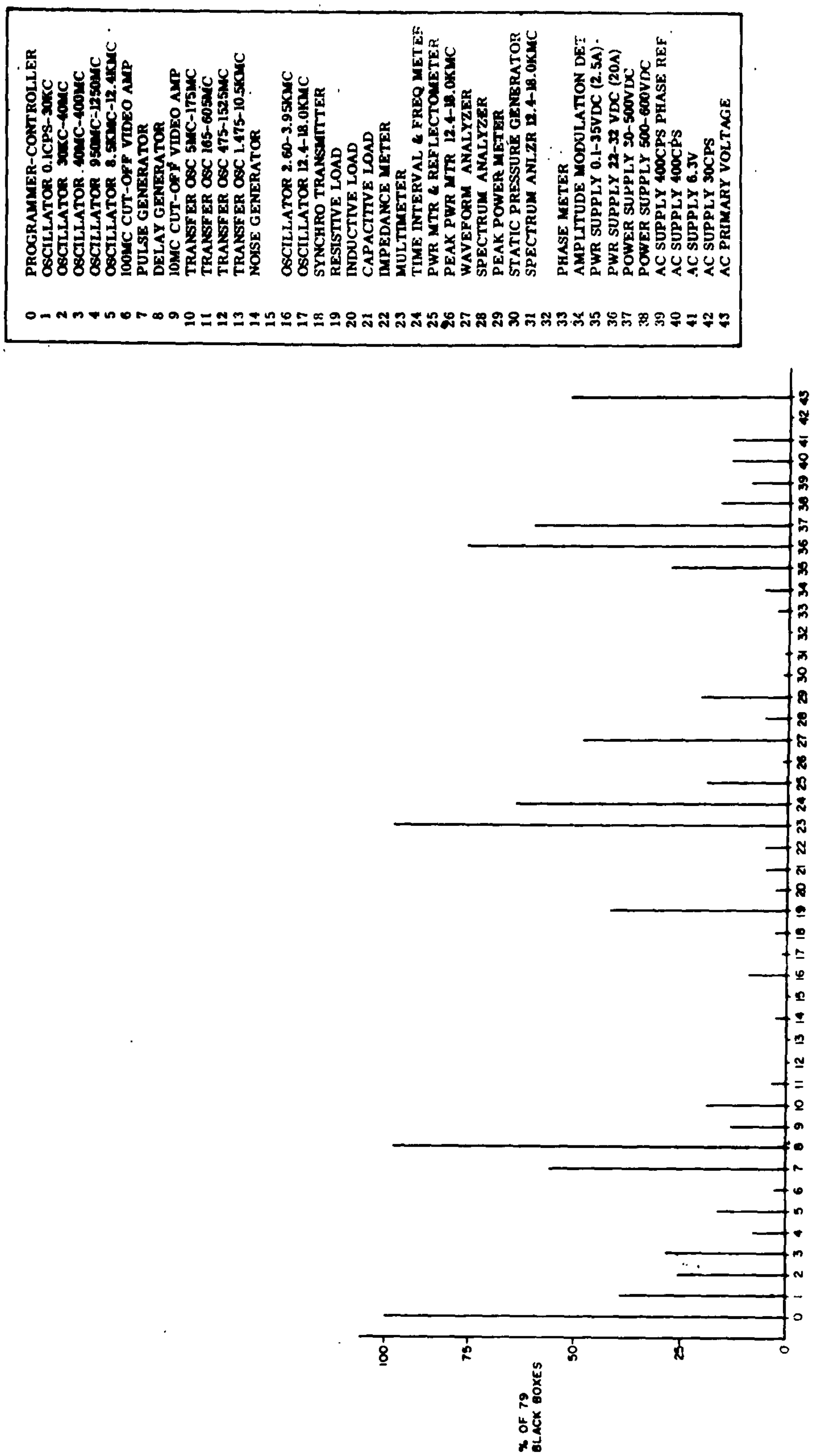


Figure 35. Building Block vs Frequency of Occurrence for Module Isolation

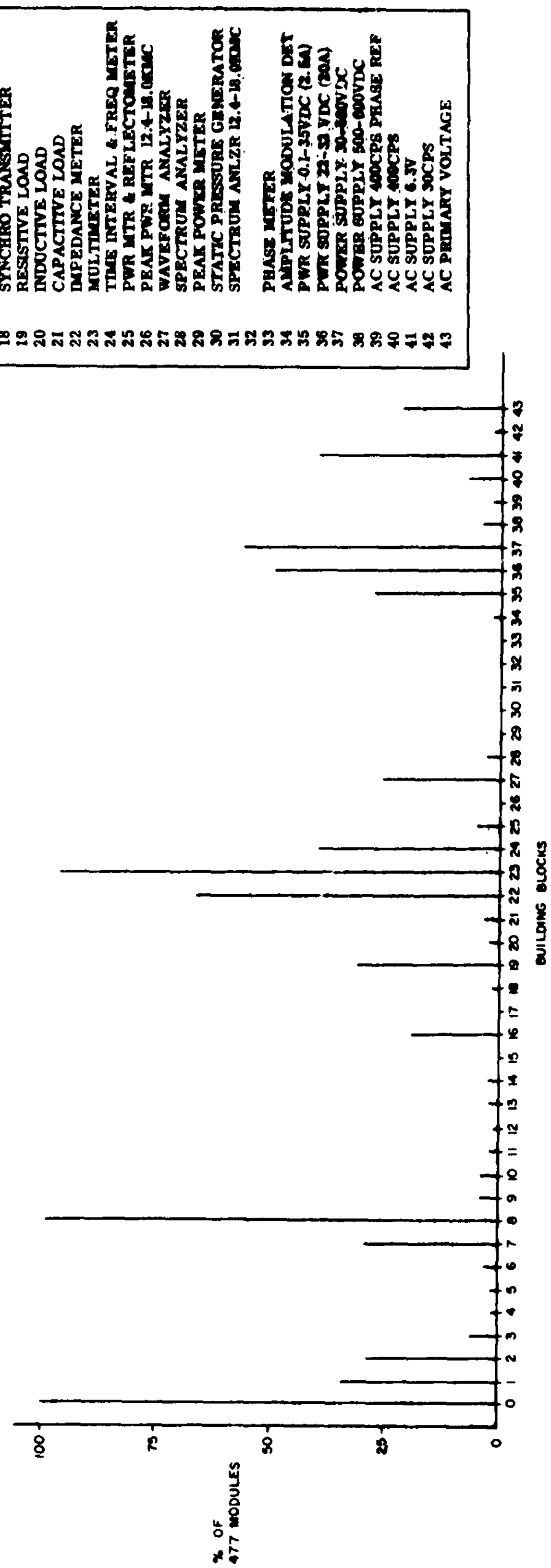


Figure 36. Building Blocks vs Frequency of Occurrence for Component Isolation

2.7.10 (contd)

In the defective component isolation the Programmer-Controller, delay generator and multimeter are used for greater than 90 percent of the modules to be tested. The impedance meter, time interval and frequency meter, power supply 0.1 - 35 VDC, power supply 30 - 500 VDC, and AC supply 6.3 volt building blocks are used to find the defective component in approximately 50 percent of the modules to be tested. It can be noted that some items are used exclusively in defective module analysis while others are employed only in defective component isolation. This explains the zero percentages for some items on both graphs.

2.8 Preliminary Results on Study of Warner Robins Equipment

2.8.1 Summary - The study of circuitry and functions of ten airborne black boxes serviced by WRAMA has been completed. Although manual participation in automated test routines is required in certain instances and some units require considerable manual overhaul effort, it is believed that application of automatic test equipment will result in a considerable increase in output production and reliability.

Study of WRAMA equipment indicates that, in addition to building blocks already specified, one new building block is needed: an A.C. high pot supply. All other stimulus and response requirements are met by existing building blocks and by specification changes to the 400 cps power supply, phase referenced and to the synchro transmitter and building block specifications.

2.8.2 General - Stimulus, response measurement and load requirements for the following black boxes have been determined and are shown in Figure 37.

a. AN/ASB-4

1. Velocity Integrator
2. Range Integrator
3. Longitudinal Data Computer
4. Heading Error Computer
5. Radar Receiver/Transmitter Unit

b. A3A

1. Servo Central
2. Computer Central
3. Target Position Computer
4. Pulse Sweep Generator

c. K-4A

1. Stabilization Amplifier

Differences between the AN/ASB-4 and AN/ASB-9 and differences between the A3A and MD-9 have only a minor bearing on their respective checkout procedures. Tentative specifications for new building blocks required are:

Precision frequency 400 cps, 2 phase supply requirements

Input voltage	105-125 VAC
Input frequency	55-420 cps
Output frequency	400 cps + 0.1%
Output voltage	115 V ±1% fixed
Output phases	2 phase
Output power	500 volt amperes

Figure 37

WRAMA Airborne Equipment Survey
Building Block Requirements

		1. Vel. Integrator ASB4	2. Range Integrator ASB4	3. Long. Data Comp ASB4	4. Heading Error Computer ASB4	5. Radar Trans. Rec. ASB4	6. Servo Central A3A	7. Computer Central A3A	8. Target Pos. Comp. A3A	9. Pulse Sweep Gen. A3A	10. Ampl. Racks K-4A
0	Programmer-Controller	X	X	X	X	X	X	X	X	X	X
1	Oscillator 0.1 cps - 30 KC										X
2	Oscillator 30 KC - 40 MC								X	X	
3	Oscillator 40 MC - 400 MC					X					
4	Oscillator 950 MC - 1250 MC										
5	Oscillator 8.5 Kmc - 12.4 Kmc					X					
6	100 Mc Cut-Off Video Amp										
7	Pulse Generator					X			X	X	
8	Delay Generator	X	X		X		X	X			
9	10 Mc Cut-Off Video Amp										
10	Transfer Osc 5 Mc - 175 Mc										
11	Transfer Osc 165 - 605 Mc										
12	Transfer Osc 475 - 1525 Mc										
13	Transfer Osc 1.475 - 10.5 Kmc										
14	Noise Generator										
15	Calibrated Waveguide Ant.					X					
16	Standard Gain Horn Antenna										
17	Synchro Transmitter/Ratio Transformer	X	X	X	X		X	X			
18	Resistive Load	X	X	X				X			X
19	Inductive Load	X	X		X		X	X			
20	Capacitive Load										
21	Impedance Meter										
22	Multimeter	X	X	X	X	X	X	X	X	X	X
23	Time Interval & Freq. Meter	X			X		X	X		X	
24	Power Meter & Reflectometer					X					
25	Wavemeter (Absorption type_					X					
26	X Band Noise Generator					X					
27	Waveform Analyzer								X	X	
28	Spectrum Analyzer					X					
29	Peak Power Meter					X					
30	Static Pressure Generator										
31	Thermocouple Voltmeter										
32	Phase Meter (RF)										
33	Amplitude Modulation Det										
34	Power Aupply .1-35V 2.5A DC						X	X			

Figure 37 (contd)

WRAMA Airborne Equipment Survey
Building Block Requirements
(Contd)

		1. Vel. Integrator ASB4	2. Range Integrator ASB4	3. Long. Data Comp ASB4	4. Heading Error Computer ASB4	5. Radar Trans. Rec. ASB4	6. Servo Central A3A	7. Computer Central A3A	8. Target Pos. Comp. A3A	9. Pulse Sweep Gen. A3A	10. Ampl. Racks K-4A
35	Power Supply 22-32V 20A DC	X		X		X	X	X	X	X	X
36	Power Supply 30-500 Vdc					3	4	4	3	3	2
37	Power Supply 500-6000 Vdc									X	
38	AC Supply 400 cps Phase Ref	X	X	X	X		X	X			
39	AC Suppl7 400 cps 16-300V 7 amp										X
40	AC Supply 6.3V					X	X	X	X	X	
41	AC Supply 30 cps										
42	AC Primary Voltage 3 ϕ					X	X	X	X	X	
43	AC Supply 600 to 1800 VAC (Hi pot tester)						X	X			

A.C. High Pot Supply

Input voltage	105-125 VAC
Input frequency	55-420 cps
Output range	600 VAC rms - 1800 VAC rms
Output current	10 ma.

Output voltage increments - 100 volts, programmable
Output voltage accuracy $\pm 2\%$ of programmed value
Short circuit protection shall be provided.

Programmable Ratio Transformer

Frequency range	50 cps - 2000 cps
Maximum input voltage	.35 f (f in cps) 350 V max. above 1000 cps
Resolution	1 part in 2^{15}
Accuracy	0.01%

The ratio transformer replaces the programmable synchro transmitter previously called out. The precision frequency 400 cps 2 phase supply requirements are combined with the AC supply, 400 cps phase referenced, building block previously defined. This is reflected in the specification included in the Appendix.

2.8.3 AN/ASB-4 Velocity Integrator, Range Coordinate Generator, Longitude Data Computer and Heading Error Computer

These units are similar in that they all utilize electromechanical positional servos as computing elements. Mechanical devices such as gear trains, clutches, differentials and switching cams are frequently employed. The basic motor generator, synchro and control transformer circuits are identical for each unit. Output shafts are driven so as to mechanically represent the computational problem derived from two or more variables. The output shafts generally drive potentiometers, cam operated switches and programming switches. The majority of dynamic tests on the above "black boxes" are as follows:

a. Measurement of resistances
b. Measurement of servo "nulling" sensitivity
c. Measurement of motor starting voltage
d. Measurement of servo follow and slewing speed
e. Measurement of potentiometer output voltages
f. Check of switch closure continuity and timing

There are no major problems that would exclude the use of automatic test equipment for these tests. Excellent circuit access is gained via the main connector plugs on the front panels. The stimuli generator and response measurement devices are straightforward and simply programmable. A question was raised by Shop Foremen as to the ability of Automatic Test Equipment to select servo motor speed of adjustment resistor values. It has been established that this function is entirely practical with little or no equipment outside the range of capabilities of that specified in the ATE study for DAAFD. A brief description is given of the likely techniques of such a measurement.

By means of a photo electric, cam operated micro switch, or electrical signal output, the shaft revolution speed is measured and digitally compared to tape programmed limits. A Go No-Go decision is automatically made on the test result. If the unit fails to meet the requirements, the resistor controlling motor speed is removed, and the terminals at its mounting place are connected to the ATE. These wires will actually be connected to the programmable resistive load unit. The ATE will command the starting of the servo-motor.

The digital comparator will sense the direction and order of magnitude of the speed error, and issue programming commands to the resistive load unit. These "commands" will effect the insertion of a resistance value that will cause the motor to approach the tape programmed limits of speed. The test cycle time will allow for the motor to achieve constant speed. Two or three cycles might be required to establish the precise optimum resistance. Such a system would also be capable of trimming the motor for equal speed in forward and reverse directions, and in adjustment of anti-drift resistors.

Excessive friction in the servos will appear as abnormally high servo-motor starting voltage. Long term monitoring of switch closures may best be handled by means of a multi-channel event-recorder. This would indicate exactly which switch missed a contact, when it occurred, and the number of times it occurred.

Some manual participation may be required in the testing of these computing units. In spite of this the dynamic test time will be drastically reduced from that required by manual testing. At this time it is not possible to accurately state the automatic test time, but as a rough guide the time could at least be reduced by one tenth.

Some of these units require considerable mechanical inspection, cleaning, lubrication, and routine adjustment. Automatic test equipment is of little assistance in these tasks. It is not readily apparent from the technical manuals how much time is required to perform these mechanical tasks. Consideration must be given to the ratio of electrical testing time to mechanical overhaul time, the greater the electrical testing time, the greater the advantage of automatic checkout. For example, if the mechanical adjustments take ten hours and the electrical test one hour, then there is little to be gained by a ten to one reduction in electrical testing time since the total time required is still 10 hours and six minutes. However, if the mechanical adjustments take 1 hour and the electrical tests ten hours, then the total time may be reduced to two hours by automatic checkout.

It is felt that a considerable increase in output production and reliability may be obtained from the application of automated tests to the computing elements reviewed.

2.8.4 AN/ASB-4 Radar Receiver/Transmitter Unit

The Receiver/Transmitter unit of the AN/ASB-4 system generates high power, short duration pulses of X band RF energy. The RF energy is fed directly to the antenna. Signals are received from the antenna from radar echos and beacons. The R/T unit contains the necessary superheterodyne circuits, IF amplification, and detection to provide a video pulse output signal. The overhaul of an R/T unit consists of the following main functional checks.

a. Tuning control unit checkout.

b. Power oscillator supply voltage and current measurements.

c. Power oscillator performance at high and low line voltage.

d. Peak power measurement.

e. IF amplifier bandwidth.

f. AFC discriminator checks.

g. VSWR measurements.

h. Attenuation measurements

i. Arc-over checks.

Considerable manual participation is required in conducting these tests. A reduction in this participation may deteriorate the efficiency of component selection and alignment tasks. The precision called for in making microwave measurements is difficult to practically reproduce in automatic equipment. A thorough overhaul of an R/T unit requires almost complete disassembly, each section of waveguide being individually examined for signs of arc-over damage and electrically checked for attenuation and VSWR. The modulator pulse transformer is housed in a container filled with oil of high dielectric strength. Extremely high voltage insulation is mandatory in this unit. These containers are rigorously checked for leaks in a gaseous leak detector facility, then refilled with oil. The AFC, IF, and video amplifiers are contained in subminiature sealed modules with no accessible test points. These items are considered discardable or possibly factory repairable, and are at present, very quickly checked by insertion into a semi-automatic test fixture.

It is felt that little advantage is to be gained by automating the testing of the R/T unit. The actual testing time is a small part of the total overhaul time as disassambly, cleaning, and assembly are relatively time consuming.

2.8.5 A3A Servo Central and Computer Central

These equipments are basically alike in physical design, employing similar modular packaging, interconnection system and overall housing. The degree of access to individual modules within the main black box has been found to be good. This is inherent due to the fact that many independent functions are performed by these units, these functions in turn driving remote equipment.

It is therefore felt that an automatic checkout system may be applied to the testing of the Servo Central and Computer Central. While the Servo Central contains the majority of the servo drive amplifiers and some servos, the Computer Central contains the actual analog computing servomechanisms. Each computer module of the Computer Central has a window through which the computer output shaft dial reading may be viewed. The test operator may view all of the dials in a Computer Central by withdrawing the main chassis from its case. It should be pointed out that manual participation is required for the calibration adjustments of the Computer Central. This involves making servo adjustments to position the computer dials so as to exactly indicate parameters consistent with known stimuli signals. Such operations would be integrated with automatic tests in the following manner.

When the automatic test program reaches a point at which a calibration adjustment is required, the program will halt and an instruction indicated. This instruction may be either a number on a digital indicator from which the calibration can be referenced from a card, or a directly printed instruction directly showing the calibration value. Upon accomplishment of the calibration, the operator restarts the program. The modules have good accessibility via their connector plugs, and diagnostic testing of modules by means of automatic equipment appears favorable. Many of the tests outlined for the servo systems of the AN/ASB-4 computer units are valid for the A3A computer servos. 400 cycle AC voltage and phase measurements, null and friction tests are predominant.

Considerable mechanical inspection and overhaul is still necessary for the motor generators, synchros and gear assemblies.

2.8.6 A3A Target Position Computer and Pulse Sweep Generator

The Target Position Computer contains the electronic video circuitry used for converting RF information from the fire control radar to target/antenna error signals for the armament computer. The Pulse Sweep Generator contains the electronic circuity necessary to produce calibrated CRT Sweep displays. The target IF amplifier and detector are included in this unit. These units are not constructed in an ideal modular fashion, and therefore do not permit rapid repair by plug in replacement modules. The equipment is comprised of four major printed circuit decks quadrantally mounted in the circular overall housing. These decks have cables with plugs interconnecting their power supply and low impedance signals. However, considerable interconnections are made to each deck using permanently soldered coaxial cables. These cables connect to the deck exactly at the appropriate circuit function point. In the event of changing a deck, some tedious unsoldering of such cables is necessary. It is therefore desirable to troubleshoot the equipment to the nearest circuit component level at once.

A good distribution of test points are provided by means of which a fault may be located to the circuit function level. This might include three tube stages of circuitry. These tubes may then be removed and adapter tube bases inserted so that the pins of each tube may be monitored for further fault isolation. It may be advantageous to insert such tube socket adapters under each tube prior to commencement of automatic checking.

Manual participation would be required in the precise adjustment and calibration of CRT sweeps and markers. There is no reason why considerable time cannot be saved by the automation of checkout of these units. There is little mechanical maintenance and adjustment unlike the servo mechanisms previously described.

2.8.7 K-4A Stabilization Amplifier

The stabilization amplifier consists of 16 modules mounted on a chassis which forms the input/output junction box and base on which main connectors are mounted. Of the 16 modules, there are 8 different types. The nature of electronic circuitry in the modules is somewhat similar. Vacuum tube push-pull servo power amplifiers are predominant. Good accessibility may be obtained via the main chassis connectors, so that a faulty module can be located by means of the application of automatic checkout to the whole unit. The modules also lend themselves favorably to automatic testing techniques. Cables and relays in the main chassis may be checked without serious problems. A little mechanical overhaul work is called for, but most of the total overhaul time for this unit is taken up by electronic tests. Maximum advantage in time saving may be gained by the automatic testing of the equipment of this type.

2.9 Overall Automation Implementation Plan

2.9.1 Summary

This section describes the pertinent phases of ATE implementation. Included is a schedule of building block deliveries and a schedule of ATE implementation for black boxes and modules of the AN/ARC-34, AN/ARC-58, AN/ARC-65, AN/ARN-21, AN/APN-59, AN/APS-42 and AN/ALT-6B based on building block availability. A maximum implementation time of 18 months is suggested as consistent with current engineering developments and practice. A minimum implementation time of 8 months is given for some black boxes and modules.

The responsibilities and tasks of program management are presented, including system detailed design efforts needed, building block subcontracting, liaison with DAAFD and support activities.

Specific development problems in spectrum and waveform analyzer design are discussed. These areas are considered the most difficult for automation due to the large number of manual operations used with corresponding manual equipment and because automated equivalent devices must duplicate cathode ray tube storage and presentation functions.

An outline of training requirements for depot personnel at the maintenance, operating, programming and supervisory levels is given. This supplements the discussion of Section 2.6 which describes the effects of ATE in logistics support personnel. Finally the integration phase of the program is discussed in terms of specific tasks to be performed at DAAFD to implement the system.

2.9.2 General

The overall automation implementation plan must provide for an orderly and efficient introduction of ATE into the depot. This plan outlines a feasible delivery schedule for the ATE building blocks. Based on preliminary information available, theplan also presents a schedule for introducing depot inventory items to the ATE operation. In consideration of the magnitude of the system development task together with schedule and technical problems anticipated, a program manager concept is advocated whereby one contractor has primary responsibility under DAAFD for the design, delivery and initial operation of the ATE. It is recommended that this program manager also design those building blocks, such as programmer controller and switching, which determined the system's inherent flexibility and capability. Other building blocks can be subcontracted to allow participation of those companies with proven experience in specific design areas.

Substantial development work is needed to produce the programmable waveform analyzer and spectrum analyzers. Design effort for the programmable oscillators will also be considerable. However, the building block specifications presented are considered realizable using existing techniques and components.

2.9.2 (contd)

The overall implementation plan must also provide for training at various levels of depot personnel. It is the intent of this plan that the depot be fully capable of the ATE operation and maintenance. This will require in addition to reliable equipment design and substantial equipment self check capability and procedures familiarization of depot personnel with ATE operation, programming and maintenance.

The ATE implementation plan concludes active participation of the program manager with an integration phase in which the system is thoroughly demonstrated and tested to the depot's satisfaction. This is also a period of familiarization when depot personnel can gradually assume operation of the system.

2.9.3 Schedule of Building Block Delivery

Figure 38 is an estimated schedule of building block deliveries expressed in terms of months required for design, fabrication and test after award of contract. The building blocks are broadly classified in three categories as 8, 12 or 18 month items. An eight month delivery time is suggested for those items where commercial equivalents exist or reasonably similar military items have been made. Design changes rather than completely new designs or complete redesigns are expected for these items, with the exception of basically simple items such as programmable loads which require new design that can be completed for eight month end item delivery. The twelve month items are those requiring some new design and techniques or major redesign of existing equipment. The eighteen month items are those requiring considerable new design and those items, such as microwave generators and transfer oscillators, whose requirements for frequency accuracy or adaptibility to remote programming are not available in commercial or existing military test equipment.

FIGURE 38

Schedule of Building Block Delivery

0	Programmer Controller	8	months
1	Oscillator 0.1 cps - 30 KC	8	"
2	Oscillator 30 KC - 40 MC	8	"
3	Oscillator 40 MC - 400 MC	12	"
4	Oscillator 950 MC - 1250 MC	18	"
5	Oscillator 8.5 KMC - 12.4 KMC	18	"
6	100 MC video Amplifier	8	"
7	Pulse Generator	12	"
8	Delay Generator	8	
9	10 MC Cut Off Video Amplifier	8	
10	Transfer Oscillator 5 MC - 175 MC	8	
11	Transfer Oscillator 165 MC - 605 MC	12	
12	Transfer Oscillator 475 MC - 1525 MC	18	
13	Transfer Oscillator 1.475 MC - 12.4 KMC	18	
14	Noise Generator	12	
15			
16	Oscillator 2.0 - 4.0 KMC	18	
17	Oscillator 12.4 - 18.0 KMC	18	
18	Synchro Transmitter Simulator (Ratio Transformer)	8	
19	Resistive Load	8	
20	Inductive Load	8	
21	Capacitive Load	8	
22	Impedance Meter	8	
23	Multimeter	8	
24	Time Interval and Frequency Meter	8	
25	Power Meter & Reflectometer	12	
26			
27	Waveform Analyzer	18	
28	Spectrum Analyzer L Band	8	
	1.2 KMC - 12.4 KMC	18	
29	Peak Power Meter	12	
30	Static Pressure Generator	8	
31	Spectrum Analyzer 12.4 - 18 KMC	18	
32			
33	Phase Meter	12	
34	Amplitude Modulation Detector	8	
35	Power Supply 0.1 V - 35 VDC	8	
36	Power Supply 22 - 32 VDC	8	
37	Power Supply 30 - 500 VDC	8	
38	Power Supply 500 - 6000 VDC	8	
39	AC Supply 400 cps Phase Ref.	10	
40	AC Supply 400 cps	8	
41	AC Supply 6.3 V	8	
42	AC Supply 30 cps	8	
43	AC primary voltage 95V - 130 V 1 ∅	8	
	104V - 130 V 3 ∅	8	
44	Transfer Oscillator 12.4 - 18 KMC	18	
45	Function Generator	12	

2.9.4 Schedule of Automating Black Box and Module Tests

Of the fifteen systems studied during Phase I of the study, it is expected that the following systems will form part of the trial ATE system workload:

AN/ARC-34
AN/ARC-58
AN/ARC-65
AN/ARN-21
AN/APN-59
AN/APS-42
AN/ALT-6B

These items are a substantial part of anticipated depot workload and have an expected inventory life of 5 to 10 years. They also represent a good sampling of equipment in the depot inventory. Figure 39 is a schedule of fully automated module isolation capability and Figure 40 is a schedule of fully automated component isolation capability. These schedules are based on the building block availability dates of section 2.9.3. In addition, it is expected that a group of newer airborne systems will also form part of the ATE work load. These are:

AN/APN-69
AN/ALT-13
AN/ALT-15
AN/ALT-16
AN/APN-113

While these systems have not been studied in detail it is expected that fully automated test capability for all module and component testing will exist eighteen months after award of contract. As in the previous case, capability for testing of some units such as power supplies, chassis wiring, and audio or low frequency circuits will exist at eight months. If due to work load demands, an accelerated automatic testing capability is required, two approaches are feasible. One is to use the ATE for all resistance, voltage and low frequency measurements starting at the eight month date and using existing mock ups and manual equipment for black box or overall system tests at benches separated from the automated installation. The other method is to introduce manual microwave generators, transfer oscillators and scope into the automated setup and to increase manual participation in the ATE test routines. This approach appears mostfeasible where few signal generator adjustments or other manual operations are needed. A disadvantage of introducing manual equipment into the automated setup is that program tapes for such an interim setup would require some modifications for fully automatic operation when the other building blocks were available. Using the first approach, program tapes could be made for resistance, continuity, AC and DC voltage tests. These comprise about eighty percent of a typical automated module test and sixty percent of black box tests. These dynamic test tapes would be made only once and could be added on to the tapes made for static testing when the building blocks for dynamic testing became available.

FIGURE 39

Schedule of Fully Automated Module Isolation

Time to Implement	Black Box
8 months	Trans. T605/ARC-58 Elect. Control Amp. AM-853/APN-59
12 months	AN/ARC-34 Receiver R761/ARC-58 Ant. Coupler CU-523/ARC-58 Ant. Coupler C-1940/ARC-58 Power Supply PP-1533/ALT6B
18 months	Receiver-XMTR RT400/ARC-65 RT-220/ARN-21 Receiver XMTR RT-289/APN-59 Azimuth & Range IP-239/APN-59 Power Supply PP-1073/APN-59 Azimuth & Range Ind. IP-268/APN-59 XMTR-Receiver RT-275/APS-42 Synchronizer SN-59B/APS-42 XMTR T608 ALT 6B

Figure 40

Schedule of Fully Automated Component Isolation

Time to Implement	Module
8 months	C-1057/ARC-34
	CY1398 RT-263/ARC-34
	MD-198 RT-263/ARC-34
	C1256 RT-263/ARC-34
	MX1489 RT-263/ARC-34
	R568 RT-263/ARC-34
	All modules AN/ARC-58 except AM1529 R 761
	All modules AN/ARC-65 except AM775A RT 400 and O - 495 RT 400
	Power Supply RT-220/ARN-21
	Chassis " "
	PP1260 RT 289/APN-59
	PP1261 RT 289/APN-59
	MX -1520 IP239/APN-59
	Chassis " "
	MX1935 PP 1073/APN-59
	MX 1933 " "
	MX 1934 " "
	Chassis AM-853/APN-59
	AR-1451 " "
	AR-1452 " "
	Azimuth SN 59B/APS-42
12 months	AM 868 RT-263/ARC-34
	R567 " "
	AM1529 R761/ARC-58
	AM 775A RT-400/ARC-65
	R. F. Osc. RT 220/ARN-21
18 months	Chassis RT 289/APN-59
	AN. Unit AS-2631/APN-59
	ANT. Assembly AS 4288/APS-42
	R.F. Oscillators #1 - #13 ALT 6B
	O.495 RT 400/ARC-65
	Mod. RT 220/ARN-21
	Freq. Mult. RT 220/ARN-21
	IF Amp. " "
	Video Decoder" "
	Range Gate " "
	Azimuth gate RT 220/ARN-21

Figure 40 (contd)

Time to Implement	Module
18 months (cont)	Azimuth control RT 220/ARN-21
	Pre Selector " "
	C1596 RT-289/APN-59
	MX2101 RT-289/APN-59
	MX1516 IP239/APN-59
	MX1517 " "
	MX1521 " "
	MX1522 " "
	MX1519 " "
	MX1518 " "
	MX1513 " "
	MX1932 PP-1073/APN-59
	MX1936 PP-1073/APN-59
	MR1525 IP-268/APN-59
	Azimuth Range IP-215/APS-42
	Mod. RT-275/APS-42
	AFC- 243 RT-275/APS-42
	Pwr. Supply PS-401 RT 275/APS-42
	Pre. Amp. AR-402
	I.F. Amp. AR-401
	Range Mark SN 59B/APS-42
	Sweep Gen. " "
	Trig. Gen. " "
	7730352G1 & 7631363G1 AN/ALT 6B
	7732064GL PP-1533/ALT 6B
	7732065G1 PP-1533/ALT 6B

2.9.5 Program Management

A program manager concept is considered most advantageous to DAAFD as an efficient and workable means of conducting this ATE program successfully through all its various phases. The program manager will have the following responsibilities:

a. System detailed design
b. Sub-contracting of building blocks
c. Liaison with DAAFD
d. Support activities

2.9.5.1 System Detailed Design

The program manager will be in the best position to assume personal design responsibility for the following items:

a. Programmer Controller design
b. Building block rack design
c. Decoder and storage design
d. Switching units design
e. Intercabling
f. Tape preparation unit or code converter unit design
g. Test bench design
h. Test fixture and adapter cable design

These are considered to be closely interrelated design areas calling for a well coordinated design effort to insure complete compatibility of these items in the completed system.

It is recommended that the program manager perform design work in the Programmer Controller and switching unit areas. These are the basic units of an automated setup and have the greatest influence in the system's flexibility, speed and utility. Likewise, address decoders and buffer storage units for message or command information can be considered as direct extensions of the P/C. The programming format adopted, signal levels used, and use of D.C. levels or pulses for control all directly affect the logical design of these elements.

The program manager may also be in the most advantageous position to design other building blocks. These may include those items whose delivery is considered critical for meeting the overall schedule or those which potential sub-contractors are reluctant to bid on at reasonable cost because of performance or delivery specifications, or the particular sub-contractor's workload with other customers

Because the building block rack design and intercabling must accommodate a wide variety of building blocks, the program manager is considered to be in the best position for their detailed specification and design. The manager will have further responsibilities of meeting overall system radio interference requirements which will also influence building block rack design. Intercabling design must take into account crosstalk problems, noise, switching transients and impedance matching as well as allowing the desired capability for flexible ATE setup, tear down and fail safe operation.

2.9.5.1 (contd)

Any tape preparation or Code Converter unit procured as part of the initial ATE system must primarily be compatible with the P/C used in this initial installation, with capability for processing tapes of other Programmer Controllers as a secondary consideration. However, by using the Code Converter specification included with this report, DAAFD can also provide for use of other existing Programmer Controllers if desired.

Initial ATE test programs with their required fixtures and adapter cables should also be made by the program manager. Setting up these first programs will be an excellent way for the program manager to judge the performance of the system and of all the building blocks. Any obvious deficiencies or shortcomings of the units will be readily noted and corrected before installation.

It is also expected that test bench design will be somewhat of an evolutionary process, changing as more inventory item test programs are worked out in order to arrive at optimum configurations. Any such design areas subject to significant change are considered best handled directly by the program manager.

2.9.5.2 <u>Subcontracting of Building Blocks</u>

A substantial amount of building block subcontracting is anticipated. This is consistent with Air Force philosophy of having well qualified subcontractors design those building blocks directly related to their particular product lines or specialties and with the project schedule requiring parallel development for a wide variety of building blocks.

A possible subdivision of building block subcontracts is:

a. Power supplies
b. Microwave devices
c. Analog to digital conversion equipment
d. Miscellaneous building blocks

Category (a) will include both A.C. and D.C. power supplies. Category (b) will include programmable L, S, X and K band oscillators, power measurement units and possibly spectrum analyzers. Category (c) will include voltage, frequency and impedance measuring devices. Category (d) will include remaining building blocks. It may be advantageous to subcontract complementary units together to the same vendor, such as X band signal generator and transfer oscillator. Less design effort duplication should result and simultaneous delivery of complementary units would be more probable. In general, both would be needed for a particular black box or module test sequence.

2.9.5.3 Liaison with DAAFD

This discussion pertains to the DAAFD - program manager relationship during the period from award of contract tohardware delivery. As part of the liaison effort, the program manager will be expected to furnish in addition to those reports required by the applicable military specifications:

a. Schedules
b. Progress letters
c. Recommended building block specification changes

As soon as DAAFD has a firm listing of inventory items for the initial ATE installation, the quantities of building blocks required should be determined. Although single quantities should suffice for most signal generators and measurements units, quantities of two to four each of the various A.C. and D.C. power supplies and loads will be needed.

It is expected that DAAFD will furnish the program manager with the following information:

a. Firm listing of inventory items to be checked out, with priority assignments.

b. List of GFE accessories for use at the depot and for loan to program manager for system tests prior to arrival of equipment at Dayton.

Other liaison tasks such as training schedules, suitable acceptance tests and participation of DAAFD personnel and services in the integration effort must be worked out jointly.

2.9.5.4 Support Activities

The program manager must be able to provide necessary support activities during the integration phase and afterwards, when DAAFD alone is operating the ATE system.

These include:

a. Spare parts support
b. Field service support
c. Programming services

2.9.5.4 (contd)

Spare parts are needed as part of the initial program. Once the system is installed at Dayton, it should be capable of normal, continuous operation to start amortizing the ATE cost and to generate new information such as ATE work standards. Just as important are first impressions created by a new and complex system. Minimum down time will create confidence in the equipment and ease the task of properly orienting shop personnel.

Apart from inherent equipment reliability, the depth of spare parts provisioning recommended will depend on the extent of depot maintenance personnel training and on the self check capabilities built into the system. If there is only a minimum of depot personnel training and ATE self check capability, this will result in the need for replacement parts at the drawer or building block level or need for factory service rather than maintenance at the depot by replacement of small modular assemblies such as plug in cards. The original spare parts provisioning list may be modified as a result of failure records kept during the integration phase and initial operations. The same considerations hold true for potential field service needs. Sound equipment design, adequate depot maintenance personnel training and comprehensive self check capability will reduce to a minimum the need for field service support after ATE implementation. However, should field service be needed, the program manager must be capable of prompt response to the depot's request.

Programming service is also considered as a support activity. In this area, DAAFD can become self supporting by training its own personnel in equipment analysis techniques and by procurement of a suitable tape preparation unit. As mentioned in Section 2.2, Code Converter, the enclosed Code Converter tape preparation unit specification can be easily modified to include programming capabilities for the P/C specified in this report.

2.9.6 Developement

The schedule for delivery of the building blocks anticipates several problem areas in development engineering. The two most troublesome areas are considered to be the automated spectrum and waveform analyzers due to:

a. Number of manual controls and adjustments found in comparable manual equipment.

b. Utilization of cathode ray tubes in manual equipment resulting in high storage and display capacities.

2.9.6.1 Spectrum Analyzer

Use of a manual spectrum analyzer involves the following operations for the most satisfactory spectrum display.

a. Tuning spectrum analyzer receiver in region of desired spectrum.
b. Adjusting input attenuation to correct setting.
c. Selecting optimum dispersion or sweep frequency range.
d. Selecting optimum sweep rate.
e. Oscilloscope adjustments (intensity, focus, centering).

There is a definite problem in signal acquisition, requiring some trial input attenuator settings and tuning the receiver over the band wherein the expected signal should fall. Using the widest dispersion initially is an aid in acquisition, but once the signal is acquired, tuning is varied to center the spectrum on the scope display and at the same time narrower dispersions are selected to give the best spectral display. A dispersion change of say 50 Mc to 10 Mc may result in loss of spectrum if the receiver was tuned greater than 10 Mc from the input signal.

In the automated spectrum analysis it is recommended that first of all a frequency measurement be made using the programmable transfer oscillators. This information can be used to set the spectrum analyzer local oscillator close to signal frequency. Ideally the programmable spectrum analyzer receiver would be set at signal frequency - 1/2 dispersion to effectively center the input spectrum over the frequency sweep range. The programmable spectrum analyzer input attenuator would have been previously programmed for the required attenuation setting, which would be determined when the test program was assembled. The programmed sweep rate will depend upon the measurement and recording technique used. Neglecting limit comparison for the moment, consider the spectrum analyzer output routed to the analog to digital converter in the ATE system. Also consider use of a ten line per second printer. If direct printout of various spectral points were desired, a 0.1 sweep per second rate will result in 100 spectral point printouts. If a 10 Mc dispersion were used these printouts occur at approximately 100 Kc increments.

It is expected that storage and sampling will be needed in this type of analog method to permit useable voltage readings at various spectral points. Otherwise for low pulse repetition frequencies and higher sweep rates, the energy available for operating a measurement device becomes less as fewer input pulses occur over the conversion or sampling time. In other words, a substitute for the storage effect of a CRT screen's persistence and operator's optical persistence is needed.

The L band spectrum analyzer specified calls out discrete crystal controlled frequency points rather than an actual frequency sweep. This is due to the TACAN pulse and spectrum characterisitcs required which are more exacting than those for a radar or an IFF pulse. Also, because TACAN transmitters are crystal controlled, there is no severe problem in signal

2.9.6.1 (contd)

acquisition for the spectrum analyzer. Measurements at fixed frequency points allows sampling over any number of transmitter pulses and an energy storage problem here does not become troublesome.

2.9.6.2 Waveform Analyzer

Investigation of the Waveform Analyzer or more correctly, waveform measuring unit, indicates that this device may be required to measure:

a. Pulse width
b. Pulse amplitude
c. Rise time
d. Decay time or fall time
e. Overshoot
f. Amplitude droop

A read-out in digital form is required for each of these characteristics with a measurement accuracy in the order of 1% to 3%.

For pulses of durations of 1 usec or more the first two characteristics can be measured with a conventional counter and a pulse amplitude averaging circuit.

For rise and decay or fall times two methods have been proposed:

a. Differentiate the waveform with a short RC time constant and apply the resultant output to a "sample and hold" circuit for subsequent discrete amplifications and ADC. This approach is almost useless as the output is a function of the rise and decay wave shape and these are seldom linear functions.

b. Average a number of the pulses to obtain a DC level equal to the maximum amplitude of the pulse and use this in analog comparator circuits to detect the 0.1 and 0.9 levels of rise and decay of the pulse. The time interval between the 0.1 comparator trigger and 0.9 comparator trigger is measured by the counter. Logic is required to achieve the correct answer for positive and negative going pulses. This method appears to have promise. Overshoot is somewhat more difficult but perhaps an analog comparator could detect the amplitude above the DC level proportional to pulse amplitude and the zero base line.

The measurement of maximum amplitude droop will require further study. As overshoot and droop are not often specified for typical Air Force black boxes and modules, the waveform analyzer specification does not include their measurement. An additional problem is that these characteristics as seen by a measuring device also depend on impedance matching between measurement device and the unit under test.

2.9.6.2 (contd)

For pulses below 1.0 usec in duration with rise times in the order of nano seconds these characteristics can be accurately measured only by unconventional counters or by using sampling techniques. Both of these possibilities are very much "state of the art" although excellent oscilloscopes are becomming available for these measurements. These state of the art techniques appear feasible unless the waveshape degrades severely i.e. no longer a pulse, in this case all the measurements and their accuracies will be affected and for this reason all answers will be suspect without an optical cross-check.

One final problem is the requirement of precise triggering as this can be quite troublesome even in a conventional scope, especially if pulse width or PRF jitter exists.

2.9.7 Training

1, The ultimate success of the ATE installation will depend upon thorough training of all [redacted] personnel concerned with this installation. Each type of [redacted] personnel, whether supervisory, operating, maintenance or engineering should receive adequate instruction in pertinent phases of ATE operation. These phases are:

a 1. ATE application.
b 2. Prime equipment analysis techniques
3. Fixture and cable engineering
4. Programming
5. ATE operating procedures
6. ATE maintenance

2.2. ATE application should be familiar to all supervisory and managerial personnel directly related to the [redacted] repair operation. The[redacted] should know precisely what kind of equipment they are getting, what its potential is in terms of testing capability, and the general problems associated with automating the testing of a black box or module. This general knowledge of the installation will result in more effective use of the ATE.

3. ~~Prime equipment analysis techniques have been described in detail in the reports under contract AF 33(604)-28541.~~ [redacted] Personnel can study [redacted] examples of equipment analysis and apply similar techniques to inventory items as they are added to the ATE workload. It is recommended that prime equipment analysis be performed by personnel in an engineering classification as determination of suitable ATE test routines and establishing limits will require sound engineering judgement.

4. [redacted] Personnel can also work with contractor personnel during the integration phase of ATE implementation to study the ATE routines used for the initial workload. The [redacted] can also specify that a particular ATE routine or routines be worked out as a joint effort with [redacted] personnel during this integtation phase.

2.9.7 (contd)

It is recommended that test fixtures and cables for a number of black boxes and modules be furnished as part of the initial ATE implementation. This is consistent with the concept of assigning a contractor responsibility for a completely integrated and workable system. These fixtures and adapters can be used as models by depot personnel in the design and fabrication of such units for other inventory items. It is expected that each fixture will incorporate a small amount of circuitry such as RF or peak detectors and precision isolation resistors. Cables will require appropriate usage of shielded and coaxial conductors. These considerations are needed to maintain measurement accuracy and to prevent test set-up induced errors due to fixture loading and cable cross coupling and loading. Depot personnel must be given adequate opportunity to learn such ATE implementation techniques and can be indoctrinated in them during the integration phase.

5 Programming is also an area definitely requiring personnel training. It is recommended that a tape program preparation unit be procured which can be operated by personnel with a minimum of programming experience. Such a unit can be of the code converting type described in this report or the same unit less some particular decoders and encoders. In any event, a keyboard employing English language key labels (such as type measurement, range, test point number, etc.,) is preferred to a unit requiring translation of commands to binary codes.

6 ~~5~~ Operation of the ATE system will also require training of [redacted] personnel. This is not expected to be a major area for training but will require some degree of indoctrination. Actual operating controls should be few in number and easily understood. Displays will be direct reading and require no scaling or interpretation. Other aspects of instruction will cover tape loading, splicing, tape search, and building block set up and tear down. Training in calibration procedures will also be needed. While a calibration check can be easily automated, calibration adjustment will probably be done manually.

6 Training in ATE maintenance will be required. The ATE will include self check and fault isolation capability. However, personnel must still be trained to use these maintainability features to fullest advantage. Instruction in theory of operation of the various building blocks and units is needed for self check features to be fully utilized. While the contractor will probably be expected to furnish tester verification tapes, these cannot be comprehensive enough to unambiguously pin point all malfunctions in a newly designed, complex ATE system. After a period of operation improved self test tapes should be made, incorporating all that has been learned of the ATE system's behavior. Sound training of operating and maintenance personnel is mandatory in order to instill confidence initially in the ATE results. Otherwise [redacted] personnel will be prone to condemn the ATE should its test results differ from those realized by manual methods on the same unit under test.

2.9.8 Integration

By integration is meant the task of setting up the ATE installation at DAAFD and performing all tasks needed to arrive at the point of carrying out depot automated repair operations. Integration will include these tasks:

a. Uncrating and physical inspection of all building blocks, benches and cables.

b. Set up and interconnection of the ATE system.

c. Checkout of the system using self test tapes and calibration chekk tapes.

d. Recalibration of units as required.

e. Demonstration of system operation by ATE checkout of previously determined inventory items.

f. Indoctrination and training of DAFD personnel.

In order to have the ATE system in operation at the earliest date, DAAFD should specify at the award of contract, a number of items for automated checkout by the system. Preparation of tapes and fabrication of adapters and fixtures can then proceed in parallel with building block fabrication. In this manner, a minimum number of contractor personnel will be required at DAAFD for integration and the automated system can start performing useful work in three or four weeks after arrival at DAAFD. Other inventory units can also be analyzed at DAAFD during setup of the ATE system to train personnel in automated test procedures as mentioned previously.

It is anticipated that the ATE installation will first be set up at the program manager's facility to insure that system performance will be satisfactory later on at the depot. These contractor tests can be conducted using inventory units on loan from DAAFD. This GFE must be in the contractor's possession if any test programs, fixtures and adapter cables are to be made up before ATE shipment to the depot.

An additional task which can be considered part of the integration phase is finalization of building block specifications. This can be intelligently done only after the trial ATE system is applied to a number of inventory items although some information for changes will become available as soon as the ATE system is put into operation.

3. Conclusions

3.1 Versatility of Recommended System

The prime objective of the automatic test equipment studies performed under Air Force Contracts AF-33(604)-28541 and AF-33(604)-32036 was to determine the feasibility and the detail requirements of a versatile automatic test system. A requirement of the system is the capability of automatically performing measurements, test, and fault isolation on electronic systems. However, it is to do this by means of a method that is not subject to obsolesence as is characteristic of most present approaches to the testing problem, such as the special purpose adapter approach.

It was desired by DAAFD to define a reliable system which by its very nature would prevent obsolesence as new electronic systems were added to the repair inventory. The solution presented in this report meets these requirements. The list of building blocks and the programmer controller as presented are considered to be capable of testing 80 percent of electronic systems present in the Air Force inventory. The very nature of the approach to the solution of the problem makes this possible. The reasons for the 80% estimate instead of 100% is the fact that all electronic systems the Air Force now has on hand were not studied. It is expected that building blocks covering the remaining r.f. frequency bands will be required in the future. Other stimulus requirements will also be found in the future. The approach to the design requirements of the stimulus generator also insures the versatility of the system. Each building block has been considered as a general purpose instrument. Consideration was given to both the requirements of the unit as per the data obtained from the study and the present state of the art in the design of the equipment. The requirements for these instruments have been chosen to permit the longest useful life possible. Also, as much as possible, anticipated future requirements for the unit have been "built in" within the limits of the state of the art.

The building block approach has the added advantage of modular construction. Obsolesence of a module or building block does not obsolete the complete system. For example an advance in the method of designing digital multimeters to greater accuracies simply implies the interchange of the newer and more accurate model for the older one. Therefore, the system as described in this report need not suffer from standardization with its implications of limited use as time introduces new testing requirements. The system described has the capability of growth and change within a realistic economic environment. The introduction of the many programmable stimulus and response generators (building blocks) will serve another important purpose. Once established and put in use they will serve as an impetus to the electronics industry to advance the state of the art. More accurate and more versatile building blocks will be made by the various electronics manufacturers specializing in the various areas. Measurement techniques will be improved upon in the competitive effort by the various manufacturers to sell the measurement and signal generating devices (building blocks). This is made possible since a manufacturer of the various building blocks need not be a large automatic test system manufacturer due to the recommended design of the equipment. The system fits well into the depot's manner of procurement and the Air Force will have many suppliers to choose from since they will not be limited in their choice to the larger electronic manufacturers.

3.1 (contd)

The discussion has been limited to the building block aspect of the automatic test system and its built-in versatility due to the approach to the solution and the physical nature of electronic system requirements. A further consideration of the system is the design approach. The approach presented in this final report under Section 2.1, General Purpose Automatic Test System Requirements, has been tested as to its applicability for use with the peripheral devices necessary in operating an automatic depot facility. The system as defined herein has the capability to be tied in with computation devices for uses ranging from the computation of problems relevent to fault isolation to the computation of logistics data necessary for supporting a repair activity.

3.2 Validity of Approach to Automation

Electronic equipments are now and have been serviced withmanually operated test instruments. From this approach checkout of electronic systems progressed into automatic and semi-automatic test equipment which, in reality, made the above manually operated test instruments programmable by some controlling equipment to perform some test functions automatically and some test functions semi-automatically. Special purpose test sets comprised partly of special purpose stimulus generators, response monitors and adapters, which may or may not have contained parts of the system under test were or are being developed. This special purpose Automatic Test Equipment performs its function for unique systems, or parts of systems, but becomes obsolete when that system is obsoleted. Several operational, or in the development stage systems, such as those for the B-58 Hustler Bomber, Atlas and Titan ICBM's and Polaris Missile are utilizing special purpose ATE.

Use of Automatic Test Equipment in a depot facility which is responsible for many different types of systems presents two additional problems to those encountered in the above listed systems. The ATE must be versatile and flexible to service many types of black boxes of many different present and future systems,

3.2 (contd)

and only a minimum quantity of hardware (such as interconnecting cables and adapters) can be obsoleted when automatically serviced end items are removed from the Air Force inventory. This requirement for a General Purpose Automatic Test System led to a building block concept as presented in this report and to time sharing of these building blocks to permit maximum utilization of hardware by negating zero output capability during end item hook-up and tear-down time.

Much effort has been expanded in studying problem area of development, installation and operation of a General Purpose Automatic Test System. Detailed plans and specifications for a prototype installation for servicing end items at the depot level of maintenance have been developed. Representative workloads of MOAMA, WRAMA, and USAF Security Services have or are in the process of being surveyed to determine any additional specifications for GPATS which are not required by DAAFD at the present time. To date, 79 black boxes and 477 modules have been analyzed.

Emphasis has been placed on peripheral equipment to perform functions for GPATS to reduce not only the GPATS operator decisions and labor but also to minimize the problems of integration with the functions for the Materiel Repair System (MRS) now being used by Air Force Depots for end item production and to maximize operational efficiency and information outputs of the test system.

The recommended approach necessitates an initial development cost. Study indicates that labor and indirect savings added to test equipment hardware savings, with a shorter lead time after continued applications of GPATS to existing and future depot workloads, amortize the development cost in a few years.

3.3 Review of Final Engineering Report on Automatic Test Equipment Study for DAAFD

Several of the results and conclusions presented in Final Engineering Report on Automatic Test Equipment Study for DAAFD have been expanded, or slightly modified during this study program. They are reviewed and discussed in this section.

1. Three different test philosophies were analyzed, and one, the recommended test system, was chosen because of its long term economic advantage over the other two discussed approaches. This consists of a time-shared Programmer-Controller operating with building blocks and several test benches. However, the building blocks were associated only with that test bench where they were being utilized. During this study effort, the possibility of time sharing some of the assembled building blocks with all of the test benches associated with a Programmer-Controller was investigated and found to be feasible. Thus, the quantity of most of the building blocks required by any depot is reduced, and this reduced quantity requirement results in reduced procurement expenditures.

   By adjusting the types of building blocks assembled at the test station, both the isolation of a defective module of a black box and the isolation of a defective piece part of a module can be performed. These steps are not necessarily performed simultaneously, or even sequentially, as the scheduling of end items for GPATS, Section 2.6.4.1 of this report, is not based on performing all steps to completely repair all black boxes of a system and all modules of a black box at one time, or in any given sequence.

   It was determined that defective modules are more economically serviced if both static and dynamic test capabilities are present at the same test station and are utilized. Of course, the module being considered must require dynamic testing to completely service it.

   Figure 41 is a reprint of the Recommended Maintenance Flow Diagram showing the System (Black Box) Test Station where defective module isolation and black box check-out (final performance) tests are performed and the combined static-dynamic test station where piece part isolation is performed. A more detailed flow diagram for the piece part isolation level of maintenance is presented in the report in Section 2.6 .

   Figure 42 is a reprint of the Recommended Test Area Layout. The quantity of ATE depicted in this figure was determined as necessary to service the end items, and workloads of these end items, analyzed during the first study effort. Obviously, the quantity of ATE shown is not valid if different end items, or workloads of these end items are considered.

   Concepts presented in the two previous figures are still valid even if end items scheduled for servicing by GPATS are not identical with end items analyzed during the first study effort.

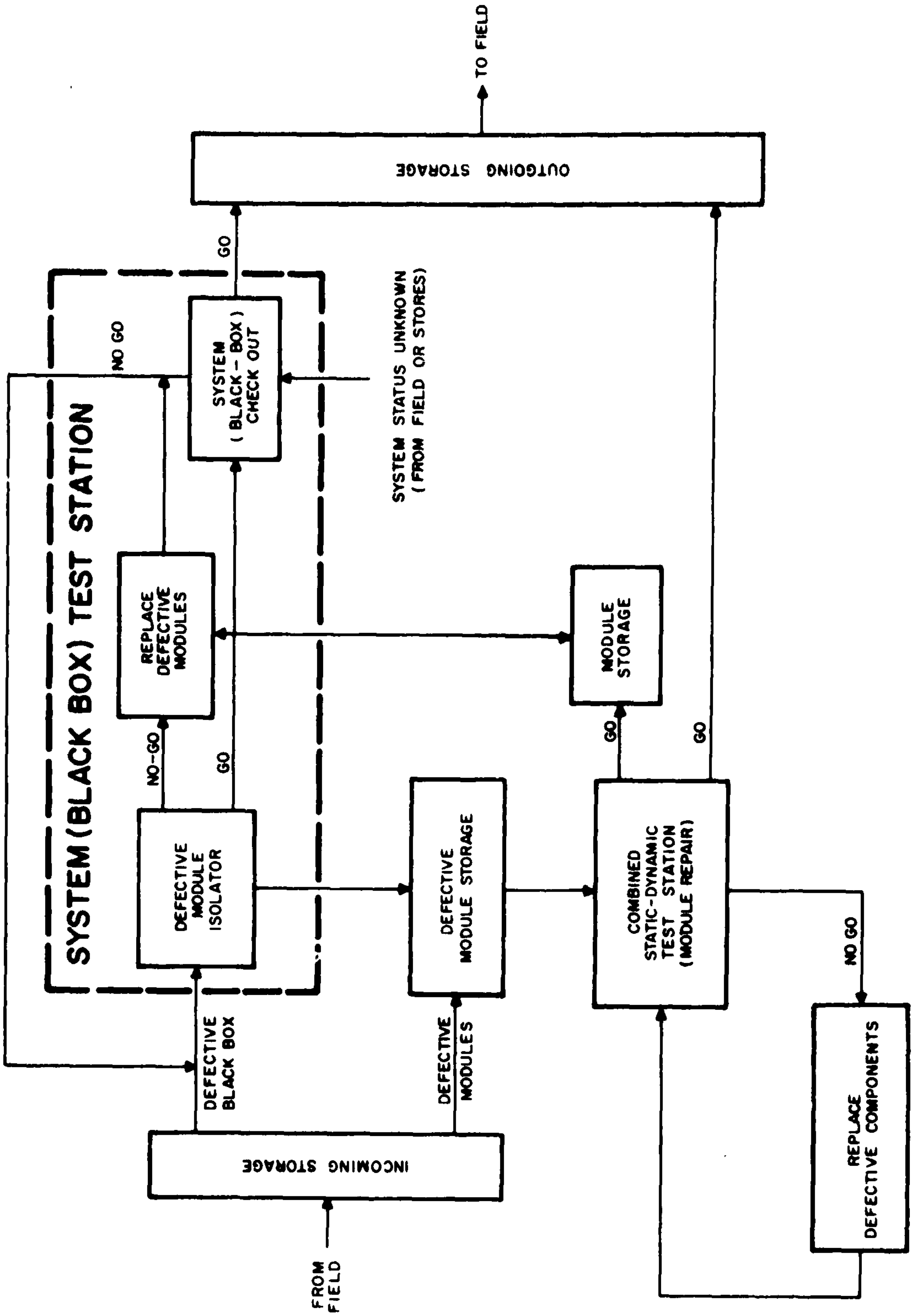


Figure 41. Recommended Maintenance Flow Diagram

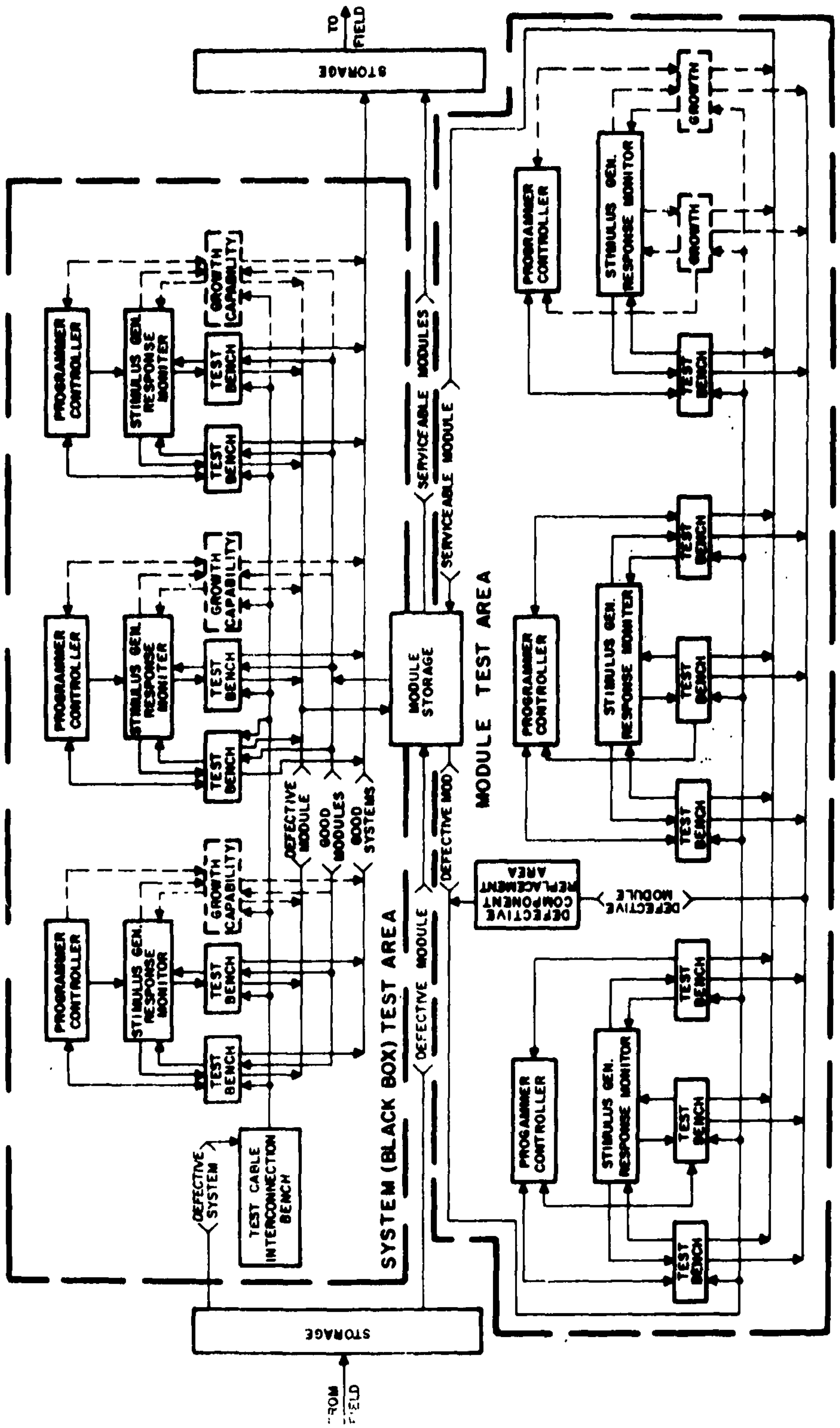


Figure 42. Recommended Test Area Layout

3.3 (contd)

2. Cost estimates as presented for procurement of ATE were based upon servicing a defined end item workload obtained from DAAFD personnel during the previous study program. The cost figures are invalid if different quantities of ATE hardware are considered. However, the cost estimates and ATE System Accumulated Savings results are further analyzed in Section 2.5 of this report to estimate more accurately the related, or indirect, savings which could be realized by applying GPATS to depot servicing of the end itemsconsidered during the first study program.

3. A Control Computer with Data Processing Capability and Code Conversion Unit are introduced and defined in this report. This peripheral equipment would, if procured, add to the block diagram of Figure 4 . Its tie-in with the General Purpose Automatic Test System follows the time sharing philosophy prevalent throughout both study programs. The Control Computer would be available for performance of many functions for any of the Programmer-Controllers present in a depot as well as performance of functions supporting the depot test area.

    Procurement of the above mentioned peripheral equipment is not part of the initial procurement plan and recommendations of this report. However, it is recommended that the peripheral equipment be procured in the future as there is a very definite requirement for equipment to perform the many functions defined in this report.

    Study results of a depot oriented Programmer-Controller, finalized after analysis of requirements generated during both study efforts, are presented in this report. With capabilities not present in operational Programmer-Controllers and in conjunction with the building blocks, the specified Programmer-Controller can perform servicing of the representative end items selected for analysis by DAAFD. In future years the complexity of electronic equipment a depot must service is expected to increase drastically, and one function of the peripheral equipment, that of performance as a Computer Controller with more advanced test capabilities than a Programmer-Controller, will become more important than at the present. For this reason, it is imperative that provision be included at this time in any hardware comprising a General Purpose Automatic Test System for integration with a Control Computer with Data Processing Capability so that this future step will not obsolete any GPATS hardware which has just been developed.

    It is emphasized that functioning as a Computer Controller is just one of the several functions the Control Computer with Data Processing Capability would perform. In fact, this feature is not considered a major function at this time as several other functions defined in this report are more important to provide the most efficient, useful and economical General Purpose Automatic Test System for performance of present depot end item servicing. Thus, functions necessary to provide integration with the peripheral equipment should be considered before and during development of any GPATS hardware.

LIST OF APPENDICES

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PURCHASE DESCRIPTION

CODE CONVERTER TAPE PREPARATION UNIT

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    - 1.1 Purpose
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3. REQUIREMENTS
    - 3.1 General Purchase Description
    - 3.2 Performance
        - 3.2.1 Service Life
    - 3.3 Design
        - 3.3.1 Controls
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            - 3.4.2.1 Eight Level Reader
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            - 3.4.2.3 Keyboard
        - 3.4.3 Decoders
        - 3.4.4 Data Storage
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        - 3.4.7 Output Devices
        - 3.4.8 Displays
        - 3.4.9 Control Circuits

ATTACHMENTS: 1) - Definitions

2) - SCATE Format

3) - Datico Format

4) - Robotester Format

Purchase Description - Code Converter Tape Preparation Unit

1. Scope

1.1 This Purchase Specification covers the detailed requirements for a code converter tape preparation unit capable of code conversion and test program tape preparation for the following Programmer-Controllers.

a. AN/GJQ-9
b. General Dynamics SCATE-203
c. Nortronics Datico DAT 001
d. Lavoie Robotester

2. Applicable Documents

MDNE-PD-63
MIL-P-26664A(USAF) 7 January 1960

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational, environmental and life requirements designated herein.

3.2.1 Service Life: 10,000 hours minimum

3.3 Design:

3.3.1 Controls:

The following front panel controls are required:

a. Power on, off
b. Input Programmer-Controller code selector
c. Output P/C code selector
d. Operation mode selection
   - Duplicate continuous
   - Duplicate row at a time
   - Input tape search forward
   - Input tape search reverse
   - Reset all data
   - Read data block
   - Read test sequence
   - Convert and punch data block
   - Convert and punch test sequence

3.3.1 (contd)

e. Printer on, off
f. Test number search selector

3.3.2 Indicators:

Indicators or indicating switches shall be provided for the control functions listed in Section 3.3.1.

3.4 Detail Performance Requirements:

3.4.1 General:

A typical functional block diagram of the code converter tape preparation unit is shown in Figure 1. This unit shall be capable of the following operations:

a. Automatic conversion of information from one Programmer Controller test tape to another. Conversion to or from a Robotester tape using another type of Programmer Controller tape shall not be required. However, the Code Converter tape preparation unit shall be capable of reading, preparing or modifying Robotester tapes.

b. Addition of test data or test sequences to the output tape.

c. Suppression of conversion of selected test data or test sequences in the input tape during the conversion process.

d. English language display of all information in the input tape for identification and varification.

e. Display of added tape information.

f. Tape preparation without an input tape by means of keyboard entries.

3.4.2 Input Devices:

The code converter tape preparation unit shall contain the following input devices:

a. Eight level perforated tape reader
b. Twelve level perforated tape reader
c. Keyboard

3.4.2.1 Eight Level Tape Readers:

The eight level tape reader shall be a photoelectric read device, capable of bidirectional drive and accommodating up to 10 1/2 inch reels.

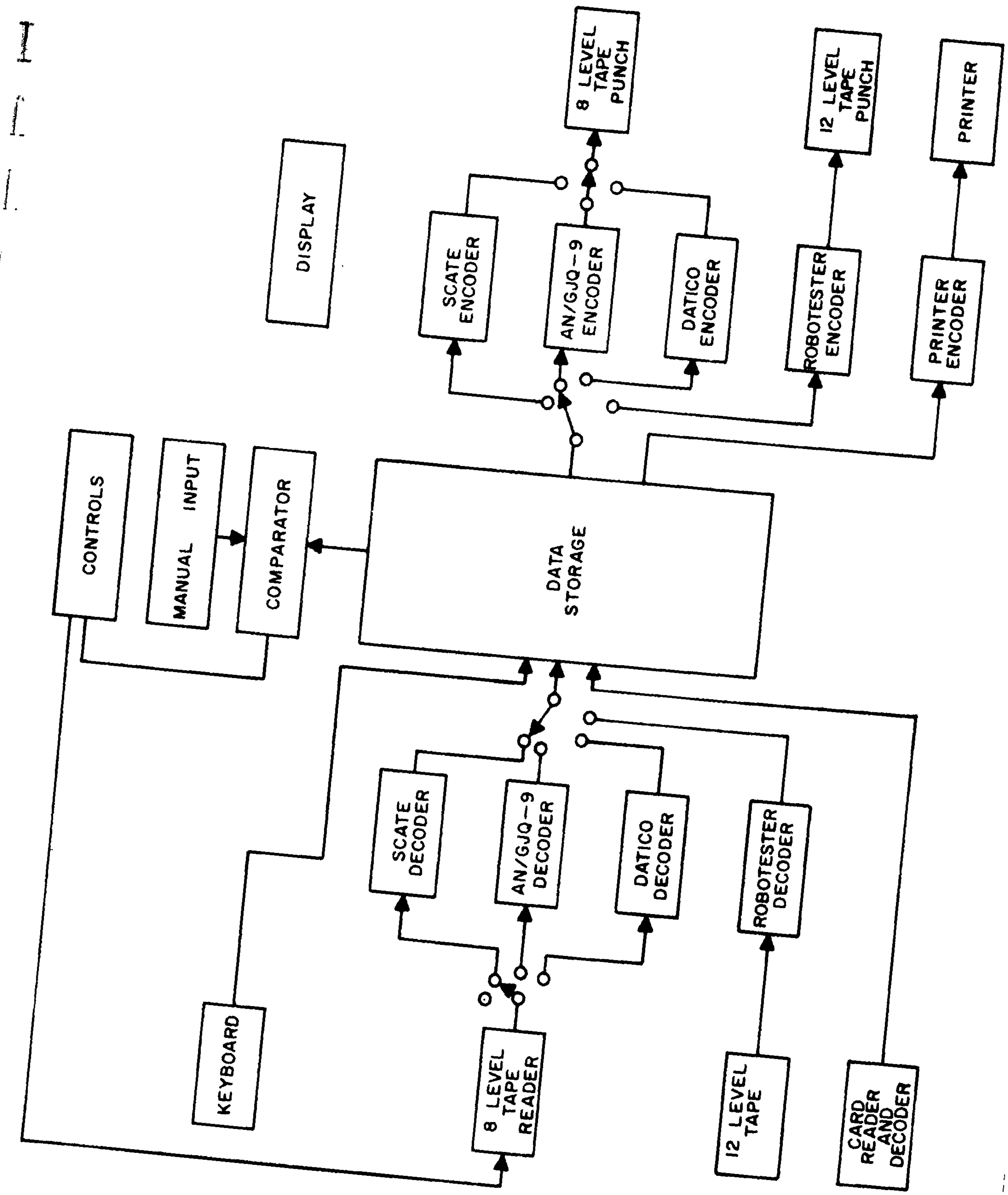


Figure 1. Code Converter Tape Preparation Unit Functional Block Diagram

3.4.2.1 (contd)

It shall be capable of reading speeds of at least 150 frames per second and stopping on a stop character.

3.4.2.2 Twelve Level Tape Reader:

The twelve level tape reader shall be a mechanical or photoelectric device capable of simultaneously reading 4 frames of tape information. It shall be capable of reading Robotester tapes at a rate of at least 4 frames per second.

3.4.2.3 Keyboard:

A keyboard shall be furnished to allow manual entry of data for preparation of new test tapes and for correcting or modifying existing tape programs. The keyboard shall be functionally arranged to provide for entry of the following data:

1. Decimal or numerical data with identification of the corresponding ATE functional unit or parameter.

2. Other test data (type measurement, range, etc.) and associated ATE functional unit or parameter identification.

3. Test sequence control data.

The decimal or numerical entry keys shall provide for entry of a six digit decimal number. Additional keys will identify the decimal entry as one of the following quantities.

a. Test number
b. High limit
c. Low limit
d. Measured value
e. Stimulus relay group
f. Stimulus relay number
g. Buffer number
h. Test point relay number
i. Timer time value
j. On off test point relay number
k. Reference input number
l. Counter limit register limit number
m. Address number
n. Sub-address number

3.4.2.3 (contd)

Provisions shall also be made to select the type of test number including primary, secondary, alternate and sub-routine and the type of test point relay such as primary or secondary. Provision shall be made to select limit polarity when limit values are used or ±, greater than (>), or less than (<) when a limit as a percentage of measured value is used for Robotester tapes.

The keyboard shall provide for entry of other test data and associated ATE functional unit or parameter identification. These include:

Address or Selection of Digital Voltmeter/Voltage Reference:

Type measurement

D.C.
A.C.
A.C. in phase
A.C. quadrature
D.C. ratio
A.C. ratio
Resistance (2 wire)
Resistance (4 wire)
Impedance
Ratio
Hi Pot
A.C. 45°

Range

.1 volt or ohm
1 volt or ohm
10 volts or ohms
1000 volts or ohms
10 K volts or ohms
100 K ohms
1 Meg ohms
10 Meg ohms
100 Meg ohms

Command

Start conversion *
Repeated conversion
Actuate
- Terminal (Minus terminal)
Standards **

* Must be followed by signal source selection
** Must be followed by standards source selection

3.4.2.3 (contd)

Address or Selection of Counter (Universal Counter Timer):

Type Measurement

Frequency
Frequency x 10
Period
Period x 10
Time
Events
Pulse Width

Range

1000
10 thousand/10KC
100 thousand/100KC
1 million/1 MC

Command

Start *
Reset
Actuate
Stop *
Sample Output *
Off
Test

Drive Selector

100 cps
1 KC
Ext. 100 cps
Ext. $\div$ 10

A Channel slope +, -
B Channel slope +, -

A Attenuator

DC x 1	AC x 1
DC x 10	AC x 10
DC x 100	AC x 100

3.4 2.3 (contd)

B Attenuator

DC x 1	AC x 1
DC x 10	AC x 10
DC x 100	AC x 100

A Trigger Level

2.0
1.5
1.0
0.5
0.0
+
-

B Trigger Level

2.0
1.5
1.0
0.5
0.0
+
-

Attenuator

.5 - 5 V
5 - 50 V
50 - 200 V

Standards

95 cps
9.5 KC

Limit Register Number

Address or Selection of Auxiliary Counter (Time Base Generator) Range:

10^{-6}

10^{-5}

10^{-4}

10^{-3}/1 ms.

3.4.2.3 (contd)

10^{-2}/10 ms.

10^{-1}/100 ms.

10°/1 sec.

10 sec.
100 sec.

Command

Start *
Stop *

Gate Duration

.01 sec.
0.1 sec.
1 sec.
10 sec.
100 sec.

Address or Selection of Comparator

High limit number
Low limit number
Limit polarity
Input
Time
Frequency
Auxiliary timer
Digital voltmeter
Digital
Events

Command
Conversion complete

Address or Selection of Timer (Delay Generator):

Time or delay number

Range

1 sec.
5 sec.

3.4.2.3 (contd)

10 sec.
25 sec.
50 sec.
100 sec.

Command

Start *
Stop *
Reset
Wait for coincidence

Address or Selection of Stimulus

Stimulus group number
Stimulus relay number
Command:
Actuate

Address or Selection of Stimulus Buffer:

Buffer Number

Command

On
Off
Reset
Transfer *
Direct transfer

Selection of Distribution Point:

Command

Reset
+ test line
- test line
External control
Reference

Selection of On-Off Level

Command:

Reset
Open
Ground
+ 28 volts

3.4.2.3 (contd)

Test Sequence Control Commands:

- Tape hold
- Tape end
- Search start *
- Search forward
- Search Reverse
- Remove hold *
- Internal switching reset
- Internal switching reset on NO-GO
- Internal switching, Do not reset on NO-GO
- Program end
- Program control
- Program stop *
- Program stop weapon system monitor

Address or Selection of Printer:

Command

- Print test no.
- Print low limit
- Print high limit
- Print measured value
- Print on-off response
- Print on GO

Signal Source Selection

- Reset
- NO-GO
- On off response
- High
- Low
- Go
- Time limit
- Program control
- Auxiliary counter gate
- Counter stop
- External signal
- Tape pulse
- + Test line
- - Test line

3.4.3 Decoders

3.4.3.1 SCATE Decoder

The SCATE decoder shall be capable of receiving a three row data block, decoding one of thirty two addresses, decoding message bits as required and routing message (instruction) information to the designated register or storage element of data storage. Refer to Attachment 2 for SCATE format.

3.4.3.2 Datico Decoder

The Datico decoder shall be capable of receiving a row of tape information, identifying and decoding an "A" row or a "C" row, and by means of decoded "A" signals route "C" row information to the designated register section or storage element of data storage. Refer to Attachment 3 for Datico format.

3.4.3.3 AN/GJQ-9 Decoder

The AN/GJQ-9 decoder shall be capable of receiving a row of tape information, identifying and decoding an address row number or a subaddress and information row and by means of address and subaddress numbers route instruction information to the designated register section or storage element of data storage.

3.4.3.4 Robotester Decoder

The Robotester decoder shall be capable of receiving a block of Robotester tape information, decoding as required and transferring information to the designated register section or storage element of data storage. Refer to Attachment4 for Robotester tape format.

3.4.4 Data Storage

The code converter tape preparation unit shall include data storage, consisting of input and output gating and sufficient storage capacity to permit storage of the lengthiest test sequences possible for any of the four Programmer Controllers referred to herein. Data storage of a test sequence is required as row by row or block by block conversion from one P/C tape to another is not feasible due to differences in the order of test data within a test sequence for each P/C. Data storage shall be capable of storing information for the following items of a test sequence:

Test number (primary)
Test number (alternate, sub-routine or secondary)
Stimulus relay selection, buffer on-off, transfer commands and signal source, reset, actuate
Type measurement
Range
Start command signal source
Stop command signal source

Sample counter output source
Counter drive
Counter limit register
Auxiliary counter start source
Auxiliary counter stop source
Auxiliary counter gate
Auxiliary counter range or time base
Counter A channel or start polarity (or slope)
Counter B channel or stop polarity (or slope)
Counter A channel attenuator
Channel B channel attenuator
Counter A channel trigger level
Counter B channel trigger level
Counter off or test
VADC conversion command signal source
Conversion complete
Timer start or reset source
Timer stop source
Timer range
Timer value
#1 Test point selection (primary or secondary, reset to or from)
#2 Test point selection
#1 Distribution point or ADC selection to comparator
#2 Distribution point
   On off test point selection
   On off detector selection
High limit or measured value
Low limit
Limit polarity or measured value polarity
Measured value tolerance
Search direction
Search start source
Reference signal selector
Reference range
Standards selection
Program stop selector
Program control or command or actuate
Program end
Tape end
Tape hold
Remove hold source
Internal switching reset
Print command

3.4.5 Comparator

A six digit parallel comparator shall be included for use in the tape search mode whereby the operator searches to a particular test number on the input tape. One input to the comparator will be from a group of six manual input switches. The second input to the comparator will be from the tape. When these two inputs coincide a comparator output signal will be available to stop the tape reader.

3.4.6 Encoders

3.4.6.1 SCATE Encoder

The SCATE encoder shall be capable of receiving information from data storage and conversion to the SCATE three row data block tape format.

3.4.6.2 Datico Encoder

The Datico encoder shall be capable of receiving information from data storage and conversion to the Datico tape format.

3.4.6.3 AN/GJQ-9 Encoder

The AN/GJQ-9 encoder shall be capable of receiving information from data storage and conversion to the AN/GJQ-9 tape format.

3.4.6.4 Robotester Encoder

The Robotester encoder shall be capable of receiving information from data storage and conversion to the Robotester tape format.

3.4.6.5 Print Encoder

The Print encoder shall be capable of receiving information from data storage and conversion to printer drive signals.

3.4.7 Output Devices

3.4.7.1 Eight Level Tape Punch

An eight level tape punch shall be provided. By means of the output P/C code selector switch, either the SCATE, Datico or AN/GJQ-9 encoder will be selected to operate the eight level punch.

3.4.7.2 Twelve Level Punch

A twelve level Robotester type punch shall be provided. When the output P/C code selector switch is in "Robotester" position, the Robotester encoder will provide signals to operate this punch.

3.4.7.3 Printer

The printer shall be a parallel entry alpha numerical recording device furnished for printout of information in data storage. A minimum of twenty printer columns shall be provided to allow printout of all decoded tape or keyboard entry information. Typical code converter print format is shown in Figure 2. Word or entries may be abbreviated as required for proposed printer column capacity. Minimum printer speed shall be four lines per second. By means of this printer, in the decode and print mode of operation, it shall be possible to produce a complete English language print-out of the information contained on an input tape.

3.4.8 Displays

The code converter tape preparation unit shall include displays consisting of lights and alpha numerical readout devices to automatically provide the operator with the following information:

a. Test number
b. Keyboard entries selected
c. Mode of operation indicators, and other switch actuation indicators as required by human engineering considerations for simple, efficient and fool proof operation of the unit.

3.4.9 Control Circuits

The code converter tape preparation unit, by means of front panel controls and internal circuits, shall be capable of the following operations:

a. Duplication - In the duplicate continuous mode an output tape shall be prepared which is identical to the input tape. Duplication, once commanded, shall continue until stopped by the operator. Using the duplicate - row at a time mode, the input tape shall advance one row at a time and a corresponding row punched in the output tape. Tape advance and duplication of the next row must be commanded by the operator.

b. Tape Search - Search to a selected test number on an input tape shall be possible by operator selection of the desired test number using front panel numerical switches. Actuation of search forward or reverse control shall result in reading of input tape test numbers into the comparator. The manually selected number shall be continuously compared to input tape numbers until coincidence occurs and the input tape stops.

c. Reset - It shall be possible to reset all elements in data storage by means of a single switch command. It shall be possible to selectively reset elements in data storage for test information deletion or modification.

Code Converter Print Format
Figure 2

FUNCTION OR UNIT	COMMAND, PARAMETER, ADJECTIVE	SIGNAL; SUB UNIT	ARITHMETIC OPR	DIGITS 100000	10000	1000	100	10	1	MULTIPLIER OR TENTHS	BASIC UNITS	NOTES
TAPE	HOLD	RESET	+	1	1	1	1	1	1	1	S	
TEST NO	FWD	NO GO	−	2	2	2	2	2	2	2	C	
SEARCH	REV	ON OFF	±	3	3	3	3	3	3	3	Ω	
ALT NO	START	HIGH	<	4	4	4	4	4	4	4	V	
COMP	INPUT	LOW	>	5	5	5	5	5	5	5	A	
TIMER	RANGE	GO	X	6	6	6	6	6	6	6	•	
COUNTR	DRIVE	TIME LIM	÷	7	7	7	7	7	7	7		
AUX CTR	READ	TAPE		8	8	8	8	8	8	8		PROGRAM CONTROL TAPE
VADC	GATE	OFF		9	9	9	9	9	9	9		
	TRIG	TIMER		0	0	0	0	0	0	0		
REF	RESET	REF								m		
SWITCH	DIST	TIME								μ		STIMULUS SWITCHING
BUFFER		FREQ								μμ		
INT SW	GROUP	AUX TIM								K		
PROGRM	RELAY	VADC								M		
TEST PT	FROM	DIGITAL								%		
ON OFF	TO	EVENTS										
PRINT	ON	ADDRESS										
STAND	OFF	LIMIT										
CTR A	TRANS	EXT										TRANSFER
CTR B	END	AUX CTR										
	POSIT	CTR STOP										POSITION
		CONTIN										
	TEST	RATIO										
	-L-H											
	-L+H	ATTEN										
	+L+H	RES										
	DC	PHASE										
	AC	PERIOD										
		WIDTH										
		DIRECT										
	HIGH	MONITOR										
	LOW	TEST NO										
	LEVEL	MEAS										
		COMMAND										
	2 WIRE	PRIMARY										
	4 WIRE	SEC										
	HI POT	CTR A										
	IMPED	LINE										
	STOP	SLOPE										
		RANGE										
		OPEN										
		GROUND										
		COINCID										

Code Converter Print Format
Figure 2

FUNCTION OR UNIT	COMMAND, PARAMETER, ADJECTIVE	SIGNAL, SUB UNIT	ARITHMETIC OPR	DIGITS 100000	10000	1000	100	10	1	MULTIPLIER OR TENTHS	BASIC UNITS	NOTES
TAPE	HOLD	RESET	+	1	1	1	1	1	1	1	$	
TEST NO	FWD	NO GO	−	2	2	2	2	2	2	2	C	
SEARCH	REV	ON OFF	±	3	3	3	3	3	3	3	Ω	
ALT NO	START	HIGH	<	4	4	4	4	4	4	4	V	
COMP	INPUT	LOW	>	5	5	5	5	5	5	5	A	
TIMER	RANGE	GO	X	6	6	6	6	6	6	6	•	
COUNTR	DRIVE	TIME LIM	÷	7	7	7	7	7	7	7		
AUX CTR	READ	TAPE		8	8	8	8	8	8	8		PROGRAM CONTROL TAPE
VADC	GATE	OFF		9	9	9	9	9	9	9		
	TRIG	TIMER		0	0	0	0	0	0	0		
REF	RESET	REF								m		
SWITCH	DIST	TIME								μ		STIMULUS SWITCHING
BUFFER		FREQ								μμ		
INT SW	GROUP	AUX TIM								K		
PROGRM	RELAY	VADC								M		
TEST PT	FROM	DIGITAL								%		
ON OFF	TO	EVENTS										
PRINT	ON	ADDRESS										
STAND	OFF	LIMIT										
CTR A	TRANS	EXT										TRANSFER
CTR B	END	AUX CTR										
	POSIT	CTR STOP										POSITION
		CONTIN										
	TEST	RATIO										
	-L-H											
	-L+H	ATTEN										
	+L+H	RES										
	DC	PHASE										
	AC	PERIOD										
		WIDTH										
		DIRECT										
	HIGH	MONITOR										
	LOW	TEST NO										
	LEVEL	MEAS										
		COMMAND										
	2 WIRE	PRIMARY										
	4 WIRE	SEC										
	HI POT	CTR A										
	IMPED	LINE										
	STOP	SLOPE										
		RANGE										
		OPEN										
		GROUND										
		COINCID										

3.4.9 (contd)

d. Reading Input Tapes - By means of operation mode switches it shall be possible to read input tapes a data block at a time or a test sequence at a time into data storage. If the printer on-off switch is on, a corresponding data block or test sequence printout will occur.

e. Conversion - By means of the Read and Convert controls, a data block or test sequence read off the input tape will be converted to the output P/C code previously selected. The output tape shall also be punched accordingly.

f. Other Control Circuits - Additional circuits for control of power, code conversion and tape program preparation shall be furnished as required to perform the functions outlined herein.

ATTACHMENT I

Definitions

1. Row: A transverse line of tape information. An eight channel tape row consists of eight information characters plus a sprocket channel character. A Robotester tape row consists of twelve information characters plus a sprocket channel character.

2. Data Block: One or more rows of tape information that commands a discrete function, such as test number, or start timer source. SCATE and Robotester use fixed length data blocks of 3 and 4 rows, respectively.

3. Test Sequence: A number of data blocks required for a complete test.

ATTACHMENT 2

SCATE-203 Program Instructions and Charts

List of Address

Address	0	hold
	1	test number
	2	test point switching
	3	
	4	reset for delay generator
	5	delay generator
	6	
	7	resistance measurement
	8	frequency and time interval measurement (counter)
	9	voltage measurement (DVM)
	10	
	11	
	12	
	13	
	14	low limit
	15	high limit
	16	stimulus switching
	17	stimulus switching
	18	stimulus switching

The controller programmer utilizes fixed block length programming as shown in Figure

The bits A1, A2, A3, B1, and B2 determine the address of the data block. The bits A8, B8, and C8 are used for parity. The remaining sixteen bits are used for programmed information.

The Programming Data is as follows:

ADDRESS 0	PROGRAM HOLD
B3	Hold for external start
C1	Hold for Delay Generator Start

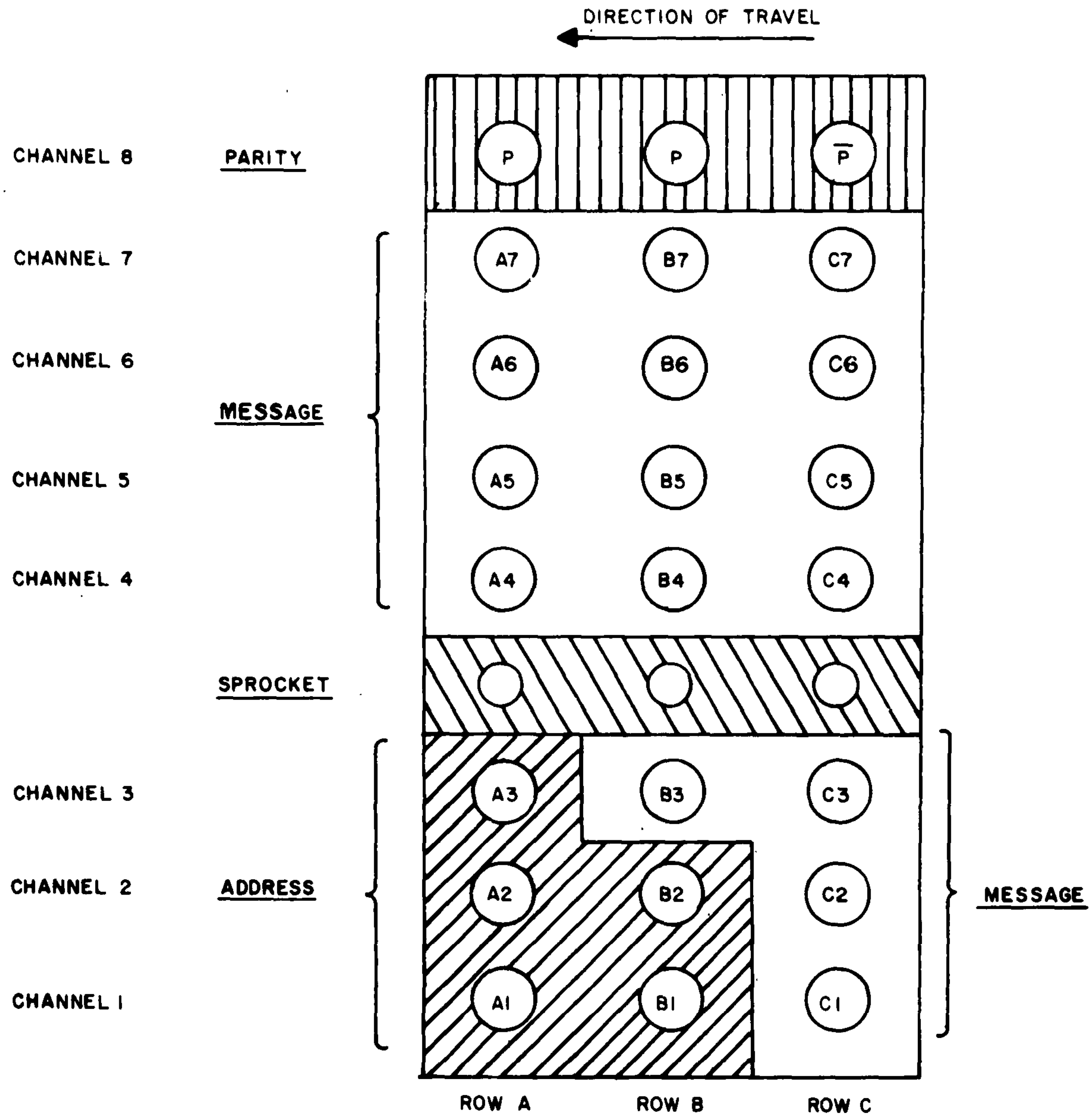


Figure 3. SCATE Tape Format

ADDRESS 1		TEST NUMBER
A4	100	
A5	200	
A6	400	
A7	800	
B4	10	
B5	20	
B6	40	
B7	80	
C4	1	
C5	2	
C6	4	
C7	8	
B3	1	Primary Test
	0	Subroutine
C1	1	Alternate Test No.
	0	Test No.
C2	1	Do not clear switching on NO-GO.
	0	Clear switching on NO-GO.

ADDRESS 2	TEST POINT SELECTOR
Group 1	A5
Brоup 2	A6
Group 3	A5, A6
Group 4	A7

B4	10	Test Line No.
B5	20	Test Line No.
B6	40	Test Line No.
B7	80	Test Line No.
C4	1	Test Line No.
C5	2	Test Line No.
C6	4	Test Line No.
C7	8	Test Line No.

Distribution Point (DP)

DP1	+ Test Line - Gnd. Side (AC, DC) (resis)	C1
DP2	- Test Line	C2
DP3	External Control	C1, C2
DP4	Reference Line - GND side for counter meas.	C3

ADDRESS 4 **DELAY GENERATOR RESET**

ADDRESS 5 **DELAY GENERATOR**

Start Source	
Tape Pulse	—
External Control	A6
Other	A7
NO-GO	A6, A7

Note: Alwaysprecede AD5 with ADD.4 on blank block to reset delay gen.

Delay Value

B4	10
B5	20
B6	40
B7	80
C4	1
C5	2
C6	4
C7	8

Range			
Value X 10^{-2}	seconds	(0 - .99 = 1 sec range)	—
Value X 1	seconds	(0 - 99 = 100 sec range)	C1
Value X 10^{-1}	seconds	(0 - 9.9 = 10 sec range)	C2

B3	0	No External Reset
	1	External Reset *
C3	0	Normal Operation
	1	Self Check

* External Reset: If the Delay Generator completes its delay prior to the receipt of the external reset signal, it will generate a NO-GO.

ADDRESS 7 **RESISTANCE MEASUREMENT**

Dec. Point	Mult.	Range	
0.00	U	0 - 10 ohm	A4
00.0	U	100	A5
.000	K	1000	A6
0.00	K	10 K	A4, A6
00.0	K	100 K	A5, A6
.000	M	1 Megohms	A7
0.00	M	10 megohms	A4, A7

C3 - Start from Delay Generator
B4 - 4 Wire Measurement

ADDRESS 8 **COUNTER**

B5 B4 Type Meas

00	Pulse Width
01	Freq.
10	Time Int.
11	Period

C7 Start Polarity

0 Neg. Pulse
1 Pos. Pulse

B7 B6 Atten. Range

00	50 - 200 v.p.p.
01	
10	0.5 - 5 v.p.p.
11	5 - 50 v.p.p.

B3 Stop Polarity

0 Neg. Pulse
1 Pos. Pulse

C6 C5 C4 Start Source

001	Ext. Line
010	+ Test
011	Delay Gen.
100	Tape Com.
100	Comp. GO

C3 C2 C1 Stop Source

001	Ext. Line
010	- Test
011	Delay Gen.
110	Comp. LO
111	Comp. HI

Measure Range

A7	A6	A5	A4		T.B.	Time Int. and P.W.	Period	Freq.	T.B.
0	1	0	0	.000 M/K	10^{-6}	.001-.999 MS	10-1KC .100-.999MS		
0	1	0	1	0.00 M/K	10^{-5}	1.00-9.99 MS	1KC-100cps 1.00-9.99MS	0.02-9.99KC	10^{-1}
0	1	1	0	00.0 M/K	10^{-4}	10.0-99.9 MS	100 cps-10 cps 10.0 ms-99.9MS	10.0-99.9KC	10^{-2}
0	0	0	0	.000 M/K	10^{-3}	.001-.999 sec			
0	0	0	1	0.00	10^{-2}	1.00-9.99 sec			
0	0	1	0	00.0	10^{-1}	10.0-99.9 sec			
1	0	0	0	.000 meg				.100MC-.999MC	10^{-3}

ADDRESS 9		AC. DC MEASUREMENT

Dec. Point	Range	
.000	1 volt	—
0.00	10 volts	A4
00.0	100 volts	A5
.000 K	1000 volts	A4, A5

Type of Measurement

DC Volts	B6
AC Volts rms	B5, B6
Normal Operate	—
Internal Standards	C4

Stop Measurement Source

None (single conv.)	—
Del. Gen	C2
Ext. Command	C1, C2

Start Measurement Source

Tape Command	—
Del. Gen.	C3
Ext. Command	B3, C3

Negative Test Line)
Chassis Ground) C6 Common Signal Source

ADDRESS 14	LOW LIMIT
A4	100
A5	200
A6	400
A7	800
B4	10
B5	20
B6	40
B7	80
C4	1
C5	2
C6	4
C7	8

B3 0 Positive Polarity
1 Negative Polarity

ADDRESS 15	HIGH LIMIT
A4	100
A5	200
A6	400
A7	800
B4	10
B5	20
B6	40
B7	80
C4	1
C5	2
C6	4
C7	8
B3	0 Positive Polarity 1 Negative Polarity
C1	0 No Print on GO 1 Print on GO
C2	0 Search on NO-GO 1 Search on GO

ADDRESS 16 THRU 31		STIMULI CONTROL SELECTOR (Switching Groups - 1 thru 10)
A4	1	
A5	2	
A6	3	
A7	4	
B4	5	Control Switch Number
B5	6	
B7	8	
C4	9	
C5	10	
C6		Sub Address 1 — Always programmed
C7		Sub Address 2
C3		
C2		
C1		
B3	0 Normal 1 Hold for external control	

ADDRESS 16 - Group 1 Stimulus
17 - Group 2 Stimulus
18 - Group 3 Stimulus

ATTACHMENT 3

DATICO SYSTEM PROGRAMMING

A. **System Requirements**

1. Power
2. Control Points
3. Instrumentation
4. Stimuli (input signals)

B **Elementary Diagram**

1. DATICO
2. Service Unit
3. System Under Test

C. **Wiring Assemblies**

1. Patchboard
2. Interconnecting Cables

D. **Tape Preparation**

1. Program Requirements
2. Punch Tape

PROGRAMMER ADDRESS ASSIGNMENT

Address	Function
A00	Timer, to position command C10 - 19 units C20 - 29 tens C30 - 39 hundreds C40 start C50 wait for coincidence
A01	Control Scanner, to position command C10 - 19 units C20 - 29 tens C30 Actuate
A02	Interrogation Scanner, to position command C10 - 19 units primary C20 - 29 tens primary C30 - 39 units secondary C40 - 49 tens secondary

ATTACHMENT 3 (contd)

Address	Function	
A02 (contd)	C50 - 59 hundreds	
	C60-UCT "A" channel	
	C70-DVM "-" terminal	
	C00-reset (after C60 or C70 has been used)	
A03	Digital Voltmeter, to position command	
	00 - 10 vdc	08 100 K ohms
	01 - 100 vdc	
	02 - 1000 vdc	09 1000 K ohms
	03 - 10 vac	
	04 - 100 vac	
	05 - 1000 vac	
	06 - ratio	
	07 - 10 K ohms	
A04	Universal Counter-Timer to Position Command	
	C11 B channel slope (+)	
	C12 B channel slope (-)	
	C13 A channel slope (+)	
	C14 A channel slope (-)	
	B channel attenuator control	
	C21 d-c 1	
	C22 d-c X 10	
	C23 d-c X 100	
	C24 a-c X 1	
	C25 a-c X 10	
	C26 a-c X 100	
	A channel attenuator	
	C31 d-c X 1	
	C32 d-c X 10	
	C33 d-c X 100	
	C34 a-c X 1	
	C35 a-c X 10	
	C36 a-c X 100	
	B channel trigger level	
	C41 - 2.0	
	C42 - 1.5	
	C43 - 0.5	
	C44 - 0.5	
	C45 - 0.0	
	C46 - 0.5	
	C47 - 1.0	
	C48 - 1.5	
	C49 - 2.0	
	A channel trigger level	

ATTACHMENT 3 (contd)

Address	Function
A04 (contd)	C51 - 2.0
	C52 - 1.5
	C53 - 1.0
	C54 - 0.5
	C55 - 0.0
	C56 + 0.5
	C57 + 1.0
	C58 + 1.5
	C59 + 2.0
	Functions
	C61 off
	C62 test
	C63 Frequency
	C64 Frequency X 10
	C65 Period X 10
	C66 Period
	Time Base
	C70 10^{0}
	C71 10^{-1}
	C72 10^{-2}
	C73 10^{-3}
	C74 10^{-4}
	C75 10^{-5}
	C76 10^{-6}

A05 Comparator high limit memory section

10 - 19	units
20 - 29	tens
30 - 39	hundreds
40 - 49	thousands
50 - 59	tens thousands
60 - 69	hundred thousands
70 -	H.L. & L.L. negative

ATTACHMENT 3 (contd)

Address	Function

A06 Comparator low limit memory section

10 - 19 units
20 - 29 tens
30 - 39 hundreds
40 - 49 thousands
50 - 59 ten thousands
60 - 69 hundred thousands
70 H.L. positive, L.L. negative

A07 Sequence indicator, to position command

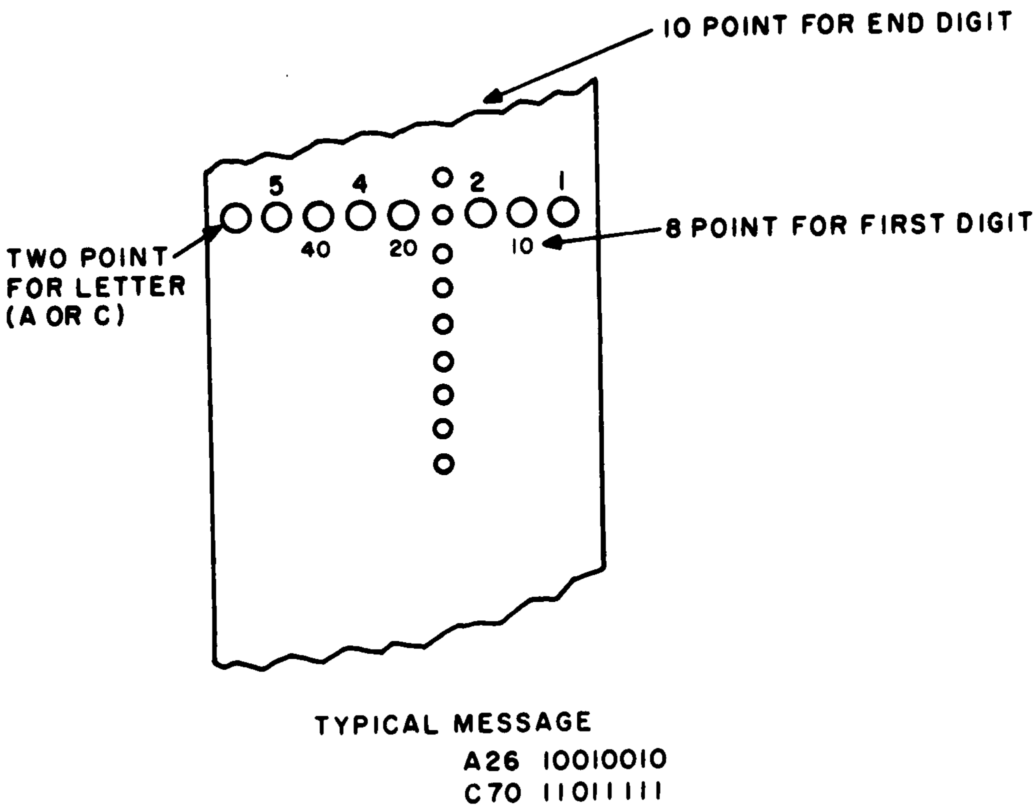
C10 - 19 units
C20 - 29 tens
C30 - 39 hundreds

A08 Indicator U.C.T. measurement, to actuate command

C00

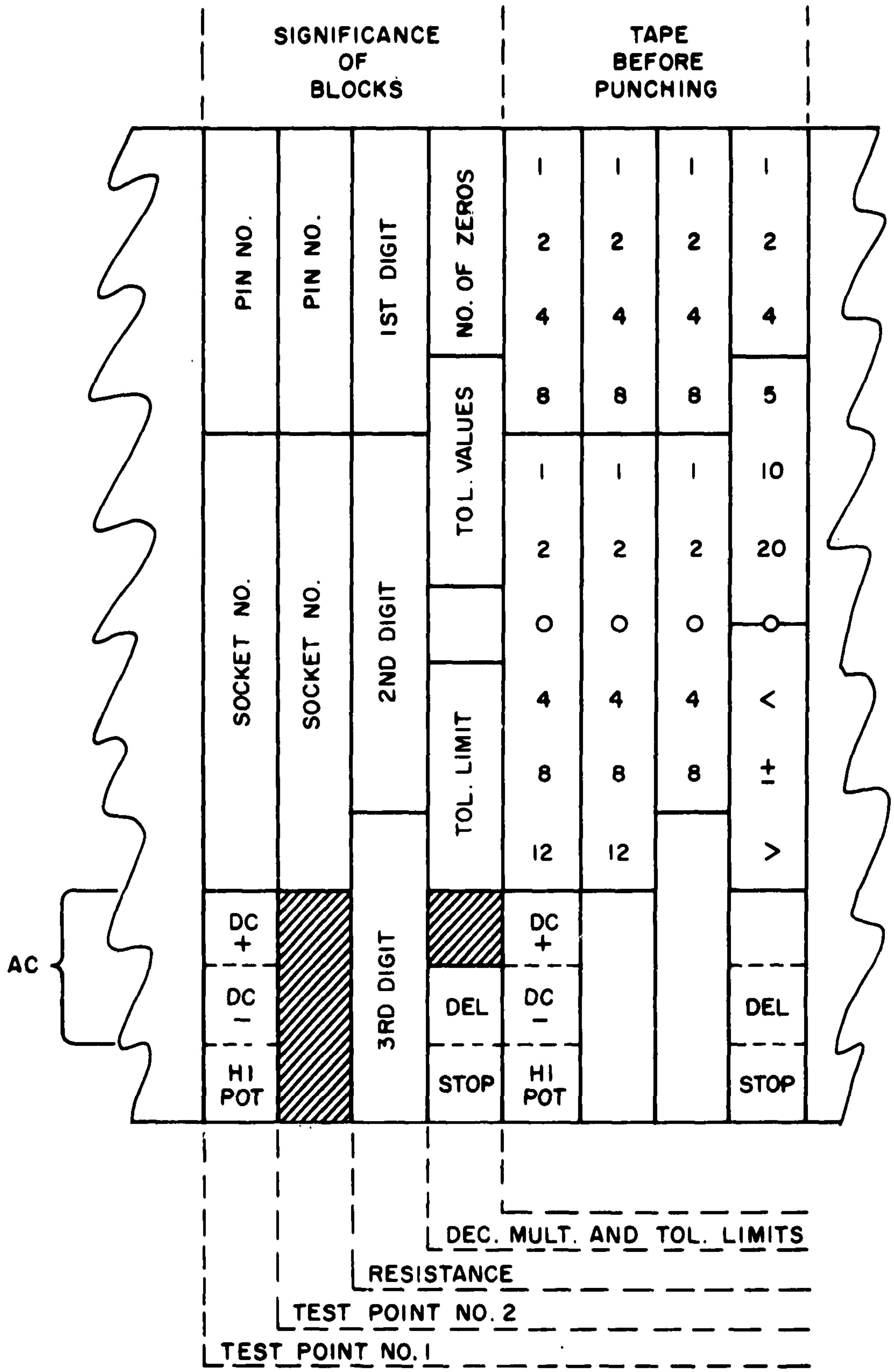
A09 Indicator D.V.M. measurement, to actuate command

C00



ATTACHMENT 3 (contd)

DATICO Tape Format



ATTACHMENT 4

Robotester Tape Format

Appendix 2
Purchase Description
Oscillator 0.1 CPS - 30 KC

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable low frequency generator. This instrument is capable of generating frequencies programmable from .1 cps to 30 KC at programmable outputs up to 30 volts.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 General

3.4.1.1 Power Requirements: 105 - 125 VAC - 50 to 420 cycles/sec single phase.

3.4.1.2 Frequency Range: .1 cps to 30 KC sine wave.

3.4.1.2.1 Frequency Accuracy .1 cps to 10 cps ± 1% of programmed value

10 cps to 100 cps ± 1% of programmed value

100 cps to 10 KC ± .05% of programmed value

10 KC to 30 KC ± .1% of programmed value

3.4.1.2.2 Distortion: Less than 1%.

3.4.1.3 Output: .1 to 10 cps 5 V max. into 600 ohm load.

10 cps to 30 KC 30 V max. into 600 ohm load.

3.4.1.3.1 Output Accuracy: .1 to 10 cps and 10 KC to 30 KC $\pm$.1 V of programmed value, 10 cps to 10 KC $\pm$ .05 V of programmed value up to 5 V, $\pm$ .1 V in the range of 5 V to 30 V.

3.4.1.3.2 Output Impedance: 600 ohms

3.4.1.4 Modulation: In the frequency range 10 KC to 30 KC output must be capable of being amplitude modulated 50% by a 35 cps square wave from external generator.

3.4.1.5 Programming: All programming will be done by applying externally supplied DC levels to control lines.

3.4.1.5.1 Frequency shall be programmable:

in .1 cps steps from .1 to 1 cps
in 1 cps steps from 1 to 10 cps
in 5 cps steps from 10 to 100 cps
in 10 cps steps from 1 KC to 30 KC

3.4.1.5.2 Output shall be programmable in 1 volt steps to 5 volts max. in the .1 to 10 cps range and in .1 volt steps to 30 V max. in 10 cps to 30 KC range.

3.4.1.5.3 Programming Time: The maximum time required to change from a given frequency and output to a new frequency and output shall not exceed 25 milliseconds.

3.4.1.5.4 Modulation shall be programmed off or on in the 10 KC to 30 KC range only.

Appendix 3

Purchase Description

Oscillator 30 KC - 40 MC

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable signal generator in the 30 KC to 40 MC range.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source

3.4 Detail Performance Requirements

3.4.1 General

3.4.1.1 Power Requirements: 105 to 125 Volts AC, 55 to 420 cycles single phase.

3.4.1.2 Frequency Range: 30 KC to 40 MC

3.4.1.3 Output Impedance: 50 ohms

3.4.1.3.1 Output Power: 10 watts

3.4.1.4 Modulation: Must be capable of being externally modulated 25 to 100% in the frequency range of 100 cps to 10 KC. 5 volts peak shall produce 100% modulation.

3.4.1.5 Frequency Accuracy: 30 KC to 100 KC ± .05% of programmed value - 100 KC to 1 MC ± .01% of programmed value - 1 MC to 40 MC .001% of programmed value.

3.4.1.6 Output Accuracy: ± 1 db of programmed value.

3.4.1.7 Programming: All programming will be done by applying externally supplied DC levels to the signal generator control lines.

3.4.1.7.1 Functions Programmed

3.4.1.7.1.1 Frequency: Frequency shall be programmable in 500 cycle steps from 30 KC to 100 KC, in 200 cycle steps from 100 KC to 1 MC and in 1 KC steps from 1 MC to 40 MC.

3.4.1.7.1.2 Output: Output shall be programmable in 10 db steps from + 40 dbm to - 120 dbm.

3.4.1.7.1.3 Modulation shall be programmed off or on.

3.4.1.7.2 Programming Time: The maximum time required to change from a given function range to a new function range shall not exceed 25 milliseconds.

Appendix 4

Purchase Description

Oscillator 40 MC - 400 MC

1. Scope

1.1 This Purchase Description covers the detailed requirements from a programmable signal generator in the 40 MC to 400 MC range.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 1000 hrs. minimum

3.3 Design

3.3.1 An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements:

3.4.1 General:

3.4.1.1 Power Requirements: 105 to 125 volts AC, 55 to 420 cycles single phase.

3.4.1.2 Frequency Range:

40 MC to 400 MC

3.4.1.3 Frequency Accuracy:

40 MC - 75 MC $\pm$ .001% of programmed value

75 MC - 400 MC $\pm$ .005% of programmed value

3.4.1.4 Output Power: 2 watts

3.4.1.5 Output Voltage: 0.1 u volt to 10 V rms.

3.4.1.6 Generator Impedance: 50 ohms

3.4.1.7 Modulation:

a. Oscillator shall be capable of 100% pulse modulation at 800 pps, 1 usec., 5 volts peak pulse from external source.

b. Oscillator shall be capable of 25, 50, 75, 100% amplitude modulation at 1 KC from external source. 3.5 volts RMS sine wave input shall result in 100% modulation.

c. Oscillator shall be capable of frequency modulation, ± 20 KC deviation at a 5 KC rate with 3.5 volt RMS input sine wave from an external source.

3.4.1.8 Programming: All programming will be done by applying externally supplied D.C. levels to the signal generator control lines.

3.4.1.8.1 Functions Programmed

3.4.1.8.1.1 Frequency: Frequency shall be programmable in 10 KC steps from 40 MC to 75 MC and in 100 KC steps from 75 MC to 400 MC.

3.4.1.8.1.2 Output: Output shall be programmable in 10 db steps from + 30 dbm to -120 dbm. Output Accuracy ± 1 db of programmed value.

3.4.1.8.1.3 Modulation: Type of modulation shall be programmable

3.4.1.8.2 Programming Time: The maximum time required to change from a given function and range to a new function and range shall not exceed 25 milliseconds.

Appendix 5

Purchase Description
Oscillator 950MC - 1250 MC

1. Scope

1.1 This purchase description covers the general and detail requirements of a programmable signal generator which generates microwave power in the frequency range of 950 to 1250 megacycles.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase description conflict, this purchase description shall govern.

3.2 Reliability

3.2.1 Service Life: 10,000 hours min. for control equipment. 1,000 hours min. for microwave tubes.

3.3 Detail Performance Requirements

3.3.1 General

3.3.1.1 Frequency Range: 950 to 1250 megacycles.

3.3.1.2 Frequency Resolution: 1 megacycle

3.3.1.3 Frequency Accuracy: ±0.001%

3.3.1.4 Frequency Stability: ±.0005% per week

3.3.1.5 Power Output Range: -10 dbm to -100 dbm in 5 db steps into coaxial load (VSWR 1.5 max.)

3.3.1.6 Power Output Accuracy: ±2.0 db

3.3.1.7 Pulse and Amplitude Modulation: Pulse, 0-6000 pps, pulse width 0.3 - 5.0 usec. from external generator, source impedance 50 ohms. Sinusoidal amplitude modulation, 15 - 135 cps, external generator, source impedance 50 ohms, modulation depth 15% - 30%.

3.3.2 Programming

3.3.2.1 Program Code: 8-4-2-1 BCD

3.3.2.2 Programming Devices: Solid state and electromechanical switches.

3.3.2.3 Programmed Functions:

a. External line supply

b. R.F. frequency

c. R.F. power

d. Mode C.W./Pulsed/Sinusoidal modulation

3.3.2.4 Programming Time: 3 seconds maximum

3.3.2.5 Warm Up Time: 5 minutes maximum

Appendix 6

Purchase Description
Oscillator 8.5 KMC - 12.4 KMC

1. Scope

    1.1 This purchase description covers the detailed requirements for a programmable signal generator in the 8.5 to 12.4 KMC range.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

    3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

    3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

        3.2.1 Service Life: 10,000 hours min. for control equipment.
        1,000 hours min. for microwave tubes.

    3.3 Design

        3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

    3.4 Detail Performance Requirements

        3.4.1 General

            3.4.1.1 Power Requirements: 105 - 125 volts AC, 55 to 420 cycles single phase.

            3.4.1.2 Frequency: 8.5 to 12.4 KMC

            3.4.1.3 Frequency Accuracy: .001% of programmed value. Stabilization time 3 seconds max.

            3.4.1.4 Frequency Stability: $\pm$.0005% per week

            3.4.1.5 Output: +40 to -100 dbm, 50 ohms

            3.4.1.6 Modulation: Unit shall be capable of being externally amplitude modulated by a .3 to 4.5 usec pulse at a pulse rate of 180-2000 pps and/or a 10 to 500 cps sine wave. A 10 volt peak pulse and/or sine wave from a 50 ohm source shall result in 100% modulation.

3.4.1.7 Output Absolute Accuracy: ± 2 dbm of programmed value.

3.4.1.8 Programming: All programming will be done by applying externally supplied DC levels to the signal generator control lines.

3.4.1.9 Program Code: 8-4-2-1 BCD

3.4.1.10 Functions Programmed:

3.4.1.10.1 Frequency: Frequency shall be programmable in 1 MC steps from 8.5 to 12.4 KMC.

3.4.1.10.2 Output: Output shall be programmable in 5 db steps from + 40 to - 100 dbm.

3.4.1.10.3 Modulation: Modulation shall be programmable as CW, pulse, sine wave, sine wave and pulse.

3.4.1.10.4 Programming Time: The maximum time required to change from a given function and range to a new function and range shall not exceed 25 milli-seconds.

Appendix 7

Purchase Description
100 MC Video Amplifier

1. <u>Scope</u>

1.1 This Purchase Description covers the general and detail requirements for a wide band AC amplifier.

2. <u>Applicable Documents</u> (MDNE-PD-63)

3. <u>Requirements</u>

3.1 <u>General Purchase Description</u>: The requirements of general purchase description No. MDNE-PD-63 apply as requirements for this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 <u>Reliability</u>

3.2.1 Service life. 10,000 hrs. min.

3.3 <u>Detail Performance Requirements</u>

3.3.1 Frequency Response. When operating into matched load it shall be down no more than 3 db at 100 KC and 120 MC.

3.3.2 Gain shall be approximately 20 db, adjustable by 6 db.

3.3.3 Input impedance 200 ohms.

3.3.4 Output impedance 300 ohms

3.3.5 Noise figure less than 10 db.

3.3.6 Rise time approximately .003 usec. (10% to 90%) with no appreciable overshoot.

3.3.7 Delay characteristics shall be approximately .014 usec.

3.3.8 Maximum output voltage shall be 15 volts peak to peak.

Appendix 8

Purchase Description

Programmable Pulse Generator

1. Scope

1.1 This purchase description covers the general and detail requirements of a programmable pulse and pulse code generator which generates pulses, pulse pairs, and bursts.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General purchase description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 Detail Performance Requirements

3.2.1 General

3.2.1.1 Input Power: 105 to 125 VAC, 55 to 420 cps single phase. Neutral must be kept floating and isolated.

3.2.1.2 Warm Up Time: 30 sec. max.

3.2.1.3 Life Expectancy (Service Life): 10,000 hours min.

3.2.1.4 Modular Construction: The pulse generator shall comprise the following modules, as needed:

a. Stable oscillator(s), fixed frequency dividers (4 decades), and frequency selection gates.

b. Three-decade program storage and counter, fast preset (two to four required).

c. Three-decade program storage and counter, slow preset (two required).

d. Sequence control logic.

e. Output amplifiers and attenuators.

3.2.2 Programming

3.2.2.1 Code: All numerical values shall be expressed in the 8-4-2-1 BCD code (with the most significant digit allowed values up to 15).

3.2.2.2 Program Command: Program information shall be received as logic levels on a "message bus", on which the information content shall not change more than once per millisecond.

3.2.2.3 Programming Time: The maximum time required to change from a given program to a new program shall not exceed 6 milliseconds per address plus 10 milliseconds for relay operation. No more than six addresses shall be required to set up a completely new program.

3.2.2.4 Functions to be programmed:

a. Pulse repetition rate (in terms of period).
b. Triggering/gating: internal standard, internal alternative, or external source.
c. Pulse width.
d. Pulse code (pairs, burst, etc.).
e. Pulse interval (pair or burst).
f. Pulse amplitude and polarity.
g. Modulation, amplitude; selected discrete functions.

3.2.2.5 Program Indicators: Provision shall be made for monitoring the state of each program storage register.

3.2.3 Frequencies Generated

3.2.3.1 Stable Oscillator: The frequency of the local oscillator shall be 10 megacycles per second, accurate to one part in 10^7 per week or better. Provision shall be made for a second oscillator of similar physical dimensions and power requirements, with output frequency between one and ten megacycles as required for special purposes.

3.2.3.2 Fixed-Frequency Square Waves: By frequency division alternately by factors of two and five, the following fixed frequencies shall be generated as square waves with nominally 50% duty cycle, and less than 10% overshoot and droop:

10 MC			
5 MC	500 KC	50 KC	5 KC
1 MC	100 KC	10 KC	1 KC

It shall be possible, under program control, for this divider chain to be driven by the second oscillator mentioned in the preceding paragraph.

3.2.3.3 Trigger Selection: Provision shall be made for programmed selection of any one of the above fixed frequencies or an

3.2.3.3 Trigger Selection (contd)

externally - supplied pulse to trigger the preset counters mentioned in subsequent paragraphs. To obtain timing accuracy, the trigger pulse should rise 10 volts in 0.05 usec; but the counters shall be capable of counting pulses with rise times up to 1.0 usec., without supplementary pulse shaping circuits. For slower pulses and sine waves a Schmitt trigger circuit shall be supplied.

3.2.3.4 Programmable Frequency Divider: A three-decade interval counter shall be provided, capable of continuous operation from any of the above square-wave signals, and of being preset and resuming counting on consecutive cycles following zero readout, thus dividing the input frequency by the number programmed.

3.2.3.5 Period Ranges: By means of the above fixed and programmable frequency dividers, pulses shall be obtainable over the following intervals:

Period Range	Resolution
0.3 to 159.9 usec	0.1 usec
0.6 to 319.8 usec	0.2 usec
3.0 to 1599 usec	1.0 usec
6.0 to 3198 usec	2.0 usec
0.03 to 15.99 millisec	0.01 millisec
0.06 to 31.89 millisec	0.02 millisec
0.3 to 159.9 millisec	0.1 millisec
0.6 to 319.8 millisec	0.2 millisec
3.0 to 1599 millisec	1.0 millisec

3.2.3.6 Pulse Width: By addition of a three-decade preset counter identical to that described in paragraph 3.2.3.4, with associated control circuits, and operating from the same fixed frequencies, provision shall be made for programming the width of the output pulse over the same ranges as listed directly above. In normal use the programmed pulse width will be less than the programmed period or interval by at least twice the width resolution; however, programming of greater pulse widths shall not damage either the control or output circuits.

3.2.4 Special Output Pulse Codes

3.2.4.1 Pulse Pairs: By addition of a three-decade preset counter similar* to that described in paragraph 3.2.3.4 with associated control circuits, operating from the same fixed frequencies, provision shall be made for generating

3.2.4.1 Pulse Pairs (contd)

pairs of pulses, the interval between their leading edges being programmable over the ranges listed in paragraph 3.2.3.5.

*In normal use, the programmed pulse interval will be equal to or less than 80% of the programmed pulse period. While desirable, it is therefore not necessary that this counter be capable of being preset and resuming counting on successive cycles of the 10 MC oscillator; however, the counter shall be preset and ready to resume counting within ten microseconds after zero readout.

3.2.4.2 Pulse Trains: A three-decade preset counter shall be provided identical to that described in the preceding paragraph, with associated control circuits, and operating from one of three sources:

a. Any one of the fixed frequencies.
b. Zero-read-out of the period counter of para. 3.2.3.4.
c. External trigger pulses

By this means provision shall be made to limit the duration of a train of pulses (or pulse pairs).

a. To a programmed length of time.
b. To a programmed number of pulses.
c. By an external control

3.2.5 Output Amplitude

3.2.5.1 Programmable Amplitudes: Pulse amplitude control shall be provided by programmable amplifiers and attenuators, either plug-in subchasses or companion 19-inch rack-mounted units, and shall cover the following ranges:

Pulse Amplitudes	Resolution	Accuracy	Impedance	Rise Time
±0.1 - 10 V	0.1 V	±.05 V	50 ohms	0.05 us
±0.5 - 75 V	0.5 V	±0.1 V	93 ohms	0.05 us
± 1 - 150 V	1.0 V	±0.2 V	93 ohms	0.10 us
± 10 - 500 V	10.0 V	± 2 V	600 ohms	0.5 us

3.2.5.2 Amplitude Modulation: In the +0.5 to 75 V amplitude range, provision shall be made to supply pulses with average amplitude between +5 V and +30 V, modulated up to 50% by a sine wave signal of 0 to 10 V rms at 10 cps to 1000 cps. The rise time and fall time of the modulated pulses shall not be degraded beyond 2.5 microseconds.

Appendix 9

Purchase Description

Programmable Delay Generator

1. Scope

1.1 This purchase description covers the requirements of a single unit for generating a pulse which is delayed a discrete programmed time from an initiating or trigger signal, using vacuum tubes and/or solid state devices.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 Reliability

3.2.1 Service Life: 10,000 hours min.

3.3 Detail Performance Requirements

3.3.1 General

3.3.1.1 Warm Up Time: 30 sec. max.

3.3.1.2 Modular Construction: The delay generator shall comprise the following modules:

a. Stable oscillator, fixed frequency dividers (6 decades) and timing and frequency-selection gates.

b. Three-decade program storage and preset counter, with readout drivers.

3.3.2 Programming

3.3.2.1 Code: The three-digit numerical value of delay shall be expressed in the 8-4-2-1 BCD code, with the most significant digit allowed values up to 15.

3.3.2.2 Program Command: Program information shall be received as logic levels on a "message bus", on which the information content shall not change more than once per millisecond.

3.3.2.3 Programming Time: The maximum time required to change from a given delay value and range to a completely new delay value and range shall not exceed ten milliseconds.

3.3.2.4 Functions to be Programmed:

a. Delay range
b. Delay value
c. Start source: external, internal, or second delay generator.

3.3.3 Functional Description

3.3.3.1 Stable Oscillator: The frequency of the local oscillator shall be 1, 2, 5 or 10 megacycles per second, accurate to one part in 10^7 or better.

3.3.3.2 Fixed Frequencies Available: By means of stable frequency dividers several fixed frequencies shall be avilable to the preset counter, including at least the following:

1 MC, 10 KC, 100 CPS, 1 CPS

3.3.3.3 Delays Programmable: A three-decade preset counter, with program storage register if necessary, shall be provided. By means of selection gates and control logic, provision shall be made to operate this counter at each of the frequencies listed above, and thus to generate time delay programmable over the following ranges of values:

Delay Range	Resolution	Accuracy
3.0 to 1599 usec.	1.0 usec.	1.0 usec.
0.3 to 159.9 millisec.	0.1 millisec.	1.0 usec.
0.03 to 15.99 sec.	10 millisec.	1.0 millisec.
3.0 to 1599 sec.	1.0 sec.	25 millisec.

3.3.3.4 Start Source: Provision shall be made to select any one of the following ~~three~~ inputs as source for the timing pulse which indicates the start of the delay:

a. Program command pulse.
b. External pulse at logic levels (positive-going).
c. External pulse through 50:1 protective attenuator.

3.3.3.5 Output Pulse: At the termination of the programmed delay a positive going output pulse with a rise time of approximately 0.1 microsecond, and a duration of one to five microseconds shall be generated.

Appendix 10

Purchase Description

10 MC Video Amplifier

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable video amplifier. This amplifier is capable of amplifying frequencies up to 10 MC at given constant gains and with different input impedances.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description when the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hrs. min.

3.3 Design

3.3.1 All functions are to be performed from a remote source.

3.3.2 Power Requirements

3.3.2.1 Power Voltage: 105 to 125 volts AC single phase.

3.3.2.2 Power Frequency: 55 to 400 cps.

3.4 Detailed Performance Requirements

3.4.1 Bandpass: 3 db bandpass 1 KC to 10 MC
Response down at least 20 db per octave above 10 MC.

3.4.2 Gain: Programmable 0-10-20 db.

3.4.2.1 Gain Tolerance: $\pm$ .1db of setting.

3.4.3 Input Impedance: Programmable 50 ohms or 1 megohm.

3.4.4 Output Impedance: 50 ohms

3.4.4.1 Output Volts: 10 volts max.

3.4.5 Noise Figure: Less than 7 db.

3.4.6 Programming

3.4.6.1 All programming will be done by applying externally supplied DC levels to control lines.

3.4.6.2 Programming time shall not exceed 25 milliseconds.

Appendix 11

Purchase Description

Programmable Transfer Oscillator 5 - 175 MC

1. Scope

   1.1 This Purchase Description covers the detailed requirements for a programmable transfer oscillator and mixer for frequency measurements in the range of 5 - 175 MC.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

   3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

   3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

      3.2.1 Service Life: 10,000 hours min.

   3.3 Design

      3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

   3.4 Detailed Performance Requirements

      3.4.1 General

         3.4.1.1 Power Requirements: 105-125 VAC - 55 - 420 cps single phase.

         3.4.1.2 Sensitivity: .1 V RMS

         3.4.1.3 Frequency Range: 5 - 175 MC

         3.4.1.4 Resolution: 10 MC

         3.4.1.5 Accuracy: .00001%

         3.4.1.6 Power Output: 10 milliwatts

         3.4.1.7 Programming: All programming will be done by applying externally supplied DC levels to the transfer oscillator control lines.

3.4.1.7.1 Functions Programmed

3.4.1.7.1.1 Frequency in 10 MC steps from 5 to 175 MC.

3.4.1.7.2 Programming Time: Maximum time to change from one frequency to another shall be 25 milliseconds.

Appendix 12

Purchase Description

Programmable Transfer Oscillator 165-605 MC

1. Scope

   1.1 This Purchase Description covers the detailed requirements for a programmable transfer oscillator and mixer for frequency measurements in the range of 165-605 MC.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

   3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

   3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

   3.2.1 Service Life: 10,000 hours min.

   3.3 Design

   3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

   3.4 Detailed Performance Requirements:

   3.4.1 General

   3.4.1.1 Power Requirements: 105-125 VAC 55-420 cps single phase.

   3.4.1.2 Sensitivity: .1 V RMS

   3.4.1.3 Frequency Range: 165-605 MC

   3.4.1.4 Resolution: 10 MC

   3.4.1.5 Accuracy: .0001%

   3.4.1.6 Power Output: 10 milliwatts

   3.4.1.7 Programming: All programming will be done by applying externally supplied DC levels to the transfer oscillator control lines.

3.4.1.7.1 Functions Programmed

3.4.1.7.1.1 Frequency in 10 MC steps from 165-605 MC.

3.4.1.7.2 Programming Time: Maximum time to change from one frequency to another shall be 25 milliseconds.

Appendix 13

Purchase Description

Programmable Transfer Oscillator 475-1525 MC

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable transfer oscillator and mixer for frequency measurements in the range of 475-1525 MC.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detailed Performance Requirements

3.4.1 General

3.4.1.1 Power Requirements: 105-125 V AC 55 - 420 cps single phase.

3.4.1.2 Sensitivity: .1 V RMS

3.4.1.3 Frequency Range: 475-1525 MC

3.4.1.4 Resolution: 10 MC

3.4.1.5 Accuracy: .0005%

3.4.1.6 Power Output: 10 milliwatts

3.4.1.7 Programming: All programming will be done by applying externally supplied DC levels to the transfer oscillator control lines.

Programmable Transfer Oscillator 475-1525 MC (Contd)

3.4.1.7.1 Functions Programmed

3.4.1.7.1.1 Frequency in 10 MC steps from 475 to 1525 MC.

3.4.1.7.2 Programming Time: Maximum time to change from one frequency to another shall be 25 milliseconds.

Appendix 14

Purchase Description

Programmable Transfer Oscillator 1.475-12.4 KMC

1. Scope

   1.1 This Purchase Description covers the detailed requirements for a programmable transfer oscillator and mixer for frequency measurements in the range of 1.475-12.4 KMC.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

   3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

   3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

   3.2.1 Service Life: 10,000 hours min.

   3.3 Design

   3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

   3.4 Detailed performance requirements

   3.4.1 General

   3.4.1.1 Power Requirements: 105-125 V AC 55-420 cps single phase

   3.4.1.2 Sensitivity: .1 V RMS

   3.4.1.3 Frequency Range: 1.475 - 12.4 KMC

   3.4.1.4 Resolution: 100 MC

   3.4.1.5 Accuracy: .0005%

   3.4.1.6 Power Output: 50 milliwatts

   3.4.1.7 Programming: All programming will be done by applying externally supplied DC levels to the transfer oscillator control lines.

3.4.1.7.1 Functions Programmed

3.4.1.7.1.1 Frequency in 100 MC steps from 1.475 to 12.4 KMC

3.4.1.7.2 Programming Time: Maximum time to change from one frequency to another shall be 25 milliseconds.

Appendix 15

Purchase Description

Programmable Noise Generator

1. Scope

1.1 This Purchase Description covers the detailed requirement for a programmable noise generator. This instrument is capable of generating wide band white noise with programmable output impedances and amplitude.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description. The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessiblel location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 General

3.4.1.1 Frequency: 1 cps to 2 K MC

3.4.1.2 Output: 25 db max. programmable 1 db steps, 1 cps to 10 MC 15 db in 1 db steps, 10 MC to 2 K MC

2.4.1.2.1 Accuracy: ± .3 db

2.4.1.2.2 Output Impedance: 50, 70, 100 and 300 ohms programmable above 10 MC.

2.4.1.2.3 Output connectors BNC, SM and N

3.4.1.3 Power Requirements: 105 - 125 VAC, 50 to 400 cycle single phase.

3.4.1.4 Programming: All programming will be done by applying externally supplied DC levels to the control lines.

3.4.1.4.1 Output Programming: Output shall be programmable in 1db steps from 1 to 25db.

3.4.1.4.2 Output impedance shall be programmed to be 50, 70, 100 or 300 ohms above 10 MC.

3.4.1.4.3 Programming time shall not exceed 25 milliseconds.

Appendix 16

Purchase Description

Oscillator 2 KMC-4 KMC

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable signal generator in the 2 to 4 KMC range.

2. Applicable Documents: MDNE-PD-63

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 General

3.4.1.1 Power Requirements: 105-125 volts AC 55 to 420 cycles single phase.

3.4.1.2 Frequency Range: 2-4 KMC

3.4.1.3 Frequency Accuracy: .001% of programmed value. Stabilization time 3 seconds max.

3.4.1.4 Output: +34 to -100 dbm 50 ohms

3.4.1.5 Output Absolute Accuracy: $\pm$ 1.5 dbm of programmed value.

3.4.1.6 Modulation: The unit shall be capable of being externally amplitude modulated by a .3 to 5 usec pulse at a pulse rate of 200-3000 pps and/or a 10 to 500 cps sine wave. A 10 volt peak pulse and/or sine wave from a 50 ohm source shall result in 100% modulation.

3.4.1.7 Programming: All programming will be done by applying externally supplied DC levels to the signal generator control lines.

3.4.1.8 Program Code: 8-4-2-1 BCD

3.4.1.9 Functions Programmed

3.4.1.9.1 Frequency: Frequency shall be programmable in 10 mc steps from 2 to 4 KMC.

3.4.1.9.2 Output: Output shall be programmable in 1 dbm steps from + 34 to - 100 dbm.

3.4.1.9.3 Modulation: Modulation shall be programmable as CW, pulse, sine wave, sine wave and pulse.

3.4.1.9.4 Programming Time: The maximum time required to change from a given function and range to a new function and range shall not exceed 25 milliseconds.

Appendix 17

Purchase Description

Oscillator 12.4 KMC-18 KMC

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable signal generator in the 12.4 KMC to 18 KMC range.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 General

3.4.1.1 Power Requirements: 105-125 volts AC 55 to 420 cycles single phase.

3.4.1.2 Frequency: 12.4 KMC to 18 KMC

3.4.1.3 Frequency Accuracy: .01% of programmed value. Stabilization time 3 seconds max.

3.4.1.4 Output: + 10 dbm to - 90 dbm into 50 ohms.

3.4.1.5 Output Absolute Accuracy: $\pm$ 2 dbm of programmed value.

3.4.1.6 Modulation: Unit shall be capable of being externally amplitude modulated by a .5 to 3 usec pulse at a pulse rate of 150-2000 pps. A 10 volt peak pulse from a 50 ohm source shall result in 100% modulation.

3.4.1.7 Programming: All programming will be done by applying externally supplied DC levels to the signal generator control lines.

3.4.1.8 Program Code: 8-4-2-1 BCD

3.4.1.9 Functions Programmed

3.4.1.9.1 Frequency: Frequency shall be programmable in 10 MC steps from 12.4 KMC to 18 KMC.

3.4.1.9.2 Output: Output shall be programmable in 10 db steps from + 10 dbm to - 90 dbm.

3.4.1.9.3 Modulation: Modulation shall be programmable as CW, or pulse.

3.4.1.9.4 Programming Time: The maximum time required to change from a given function and range to a new function and range shall not exceed 25 milliseconds.

Appendix 18

Purchase Description

Programmable Ratio Transformer

1. Scope

   1.1 This Purchase Description covers the detailed requirements for a programmable ratio transformer. This instrument is capable of supplying accurate programmable AC voltages from an accurate fixed supply.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

   3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

   3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

      3.2.1 Service Life: 10,000 hours.

   3.3 Design

      3.3.1 Controls: All functions are to be performed from a remote source.

   3.4 Detailed performance requirements.

      3.4.1 Freq. Range: 50 to 2000 cycles/sec.

      3.4.2 Max. Input Voltage: .35 f (f in cps) 350 V max. above 1000 cps.

      3.4.3 Resolution: 1 part in 2^{15}

      3.4.4 Accuracy: .01%

      3.4.5 Linearity: .001%

      3.4.6 Max. effective series impedance: Resistance 2 ohms, Inductance 75 microhenries.

      3.4.7 Programming

         3.4.7.1 All programming will be done by applying externally supplied DC levels to control lines.

         3.4.7.2 Max. Programming time shall not exceed 25 milliseconds.

Appendix 19

Purchase Description

Programmable Resistive Load

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable resistive load. The device is capable of presenting various values of resistance to a unit under test.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational, environmental and life requirements designated herein.

3.2.1 Service Life: 10,000 hrs. min.

3.3 Design

3.3.1 Resistor Load: The resistor load shall be made up of 8 decade resistor loads to give values of resistance from 0.1 ohm to 5 megohm. All decade resistors shall be connected in series with each other and with the output terminals.

3.3.2 Decade Resistive Load: Each decade resistor load shall consist of four resistors with the values of 1, 2, 4, and 8 times the decade multiplier. Decade multipliers will range from 10^{-1} to 10^{+6} ohms in all integer powers of ten. The 10^{+6} decade will contain only three resistors with the values of 1×10^6, 2×10^6, and 4×10^6 ohms. Each resistor in all 8 decades will be shunted by a relay contact. All relays will be controlled by the Decoder. Relay types will include relays with high voltage contact ratings and low voltage contact ratings. Relays and high voltage contact ratings will have their contacts consecutively connected in series from the 10^6 decade through the 10^4 decade. The 10^4 decade and the 10^3 decade will be seperated by a SPDT high voltage contact relay. One position of the SPDT relay will connect the high voltage section of the resistive load to the low voltage section. The other position of the SPDT relay will switch the high voltage section of the resistive load to a high voltage lead-in terminal.

3.3.3 Cooling: The resistive load enclosure shall be cooled by forced air whenever any resistor is anticipated to exceed 50% of its power rating. The forced air shall be programmed to operate when the decoder programs the resistive load ohmic value. Forced air cooling will be disengaged at the end of the test.

3.4 Detail Performance Requirements

3.4.1 General

3.4.1.1 Output: Any value of resistance from 5 x 10^6 ohms to 10 ohms to three significant digits shall be programmable in the resistive load. Values of resistance from 1.0 ohm to 9.0 ohms shall be programmable to two significant digits and values of resistance from 0.1 ohm to 0.9 ohm shall be programmable to one significant digit.

3.4.1.2 Programming: All programming will be done by applying externally supplied d.c. levels to the resistive load.

a. Significant Digits: 12 control lines from the decoder will be used to program the three significant digits of the resistive value.

b. Resistor Multiplier: 4 control lines from the decoder will be used to supply the resistive value multiplier.

c. Selection of Forced Air: One control line from the decoder will be used to select forced air cooling when power dissipation is high.

d. High Voltage Input Connector: One control line from the decoder will be used to select high voltage input terminals for load application over 500 volts.

e. Programming Time: The maximum time required to change from one value of resistance to another shall not exceed 50 milliseconds.

f. Program Memory: Control relays and circuits shall not utilize latch-up circuits requiring external unlatch commands.

3.4.2 Load Resistors

3.4.2.1 Load Resistors from 10^4 decade through 10^6 decade.

a. Power Rating: The resistors in this decade shall be capable of dissipating 250 watts of power in free air at 25°C. Temperature rise of the resistor shall not exceed 50° centigrade above ambient temperature at rated power in free air.

b. Voltage Rating: Each resistor shall be capable of withstanding 10 kilovolts between terminals and any point on the resistor and ground.

c. Tolerance: The value of each resistor shall not deviate from its nominal value by more than 2%.

d. Temperature Coefficient: The resistance value of each resistor shall not vary more than 0.05% per degree centigrade temperature rise of the resistor.

3.4.2.2 Load Resistors in the 10^3 Decade.

a. Power Rating: The resistors in this decade shall be capable of dissipating 250 watts of power in free air at 25°C. Temperature rise of the resistor shall not exceed 50°C above ambient temperature at rated power in free air.

b. Voltage Rating: Each resistor shall be capable of withstanding 600 volts between terminals and from any point on the resistor to ground.

c. Tolerance: The value of each resistor shall not deviate from its nominal value by more than 5%.

d. Temperature Coefficient: The resistance value of each resistor shall not vary more than .005% per degree centigrade temperature rise of the resistor.

e. Inductance: Each resistor shall be non-inductive up to 10 m.c.

3.4.2.3 Load resistors for the 10^3, 10^2, and 10^{+1} decades.

a. Power Ratings: The resistors in this decade shall be capable of dissipating 100 watts of power in free air at 25°C. Temperature rise of the resistor shall not exceed 50° centigrade above ambient temperature at rated power in free air.

b. Voltage Rating: Each resistor shall be capble of withstanding 600 volts between its terminals and between any point on the resistor and ground.

c. Tolerance: The value of each resistor shall not deviate from its nominal value by more than 5%.

d. Temperature Coefficient: The value of each resistor shall not vary more than 0.005% per degree centigrade temperature rise of the resistor in free air.

e. Inductance: Each resistor shall be non-inductive up to 10 M.C.

3.4.2.4 Load Resistors for the 10^0 decade:

a. Power Rating: The resistors in this decade shall be capable of dissipating 500 watts of power in free air at 25° centigrade. Temperature rise of the resistor shall not exceed 50° centigrade above ambient temperature at rated power in free air.

b. Voltage Rating: Each resistor shall be capable of withstanding 600 volts between its terminals and between any point on the resistor and ground.

c. Tolerance: The value of each resistor shall not deviate from its nominal value by more than 3%.

d. Temperature Coefficient: The value of each resistor shall not vary more than .015% per degree centigrade temperature rise of the resistor in free air.

e. Inductance: Each resistor shall be non-inductive up to 10 M.C.

3.4.2.5 High Voltage Resistor Switching Relays:

a. Contact Voltage: Open contacts shall not break down at 10 kilovolts.

b. Maximum Contact Current: Relay contacts shall be capable of carrying 10 amperes of continuous current. Relays shall be switched cold.

c. Contact Resistance: Closed contact resistance shall not exceed 0.01 ohms.

d. Actuating Coil: The relay actuating coil shall operate from 26.5 volts d.c.

3.4.2.6 Low Voltage Resistor Switching Relays:

a. Contact Voltage: Open relay contacts shall not break down at 600 volts.

b. Maximum Contact Current: All low voltage relay contacts will be rated at 10 amperes of continuous current, except the relays in the 10^0 decade which will be rated at 25 amperes of continuous current. Relay contacts shall be switched cold.

c. Contact Resistance: Closed relay contact resistance shall not exceed 0.01 ohms.

d. Contact Capacitance: Open contact capacitance shall not exceed 0.5 uuf.

e. Actuating Coil: The actuating coil shall operate from 26.5 vdc.

3.4.2.7 Forced Air Cooling: The forced air installation shall derive its power from a 105 to 125 volt a.c. source and it shall be capable of operating from both 60 c.p.s. and 400 c.p.s. single phase frequencies.

3.4.2.8 Input Connectors: Electrical connections leading out of the Programmable Resistive Load shall be as follows:

a. One pair of high voltage connectors capable of withstanding 10 kilovolts to ground and passing one ampere of continuous current.

b. One pair of connectors rated at 600 volts and capable of passing 10 amperes of current. These connectors shall be mounted on electrical insulation capable of withstanding 10 kilovolts to ground.

c. One pair of connectors rated at 600 volts and capable of passing 25 amperes of current. These connectors shall be mounted on electrical insulation capable of withstanding 10 kilovolts to ground.

3.4.2.9 Circuit Protection: Protection shall be provided in the event of error or failure on the part of the programming so that no resistor shall be overloaded or submitted to over potential.

Appendix 20

Programmable Inductive Load

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable inductive load. This device will present inductive loading of different values to the unit under test.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase description conflict, this purchas description shall govern.

3.2 The unit shall perform its designated function successfully within the operational, environmental and life requirements designated herein.

3.2.1 Service Life: 10,000 hrs. min.

3.3 Design

3.3.1 Inductive Load: The inductive load shall have values from 3 henries to 1 millihenry. The inductive load shall be made up of 4 decade inductive loads. All decade inductive loads shall be connected in series.

3.3.2 Decade Inductive Load: Each decade shall consist of four inductors connected in series except the first decade which will consist of two inductors in series. Each inductor will be shunted by a S.p.S.T. relay contact. The value of the four inductors will be 1, 2, 4, and 8 times the decade multiplier. The first decade will have only inductance values of 1 and 2 and its multiplier will be one henry. The remaining three decades will have multipliers of 10^{-1}, 10^{-2}, and 10^{-3} henries.

3.3.3 Relay: Each inductor is associated with a control relay whose contacts shunt the inductor. The control relays will be driven by the Decoder through amplifiers if necessary.

3.4 Detail Performance Requirements

3.4.1 General

3.4.1.1 Output: Any value of inductance from 3 henries to 100 millihenries to three significant digits can be presented

across the output terminals. Values of inductance from 10 millihenries to 99 millihenries are available to two significant digits and values of inductance from 1 millihenry to 9 millihenries will be available to one significant digit.

3.4.1.2 Programming: All programming will be done by applying externally supplied d.c. levels to the programmable inductive load control lines.

a. Control Lines: 14 control lines from the decoder will be used to program the inductive load.

b. Programming Time: The maximum time required to change from one value of inductance to another shall not exceed 50 milliseconds.

c. Program Memory: Control relays and circuits shall not utilize latch up circuits requiring external unlatch commands.

3.4.2 Inductors

3.4.2.1 Inductors for the 10^{-0}, 10^{-1} and 10^{-2} decades.

a. Working Voltage: 600 V maximum.

b. Core: Magnetic toroidal.

c. Current Rating: 300 m.a. maximum continous current.

d. Tolerance: The value of inductors shall not vary more than 1% from the nominal value.

e. Temperature Coefficient: All inductors will be temperature stabilized so that they vary no more than 0.2% per degree centigrade.

f. Coil Quality: All inductors will be made from materials given the maximum Q at frequencies well below the self resonanting frequency of the inductor.

h. Self Resonant Frequency: The distributive capacitance of an inductor shall be kept to a minimum that is commensurate with good design.

i. All inductors will be hermetically sealed in a case made of low loss magnetic shielding material.

3.4.2.2 Inductors for the 10^{-3} Decade

a. Working Voltage: 500 V maximum

b. Core: Air

c. Current Rating: 300 m.a. maximum continous current

d. Tolerance: The value of the inductor shall not vary more than 2% from its nominal value.

e. Temperature Coefficient: The value of inductance shall not vary more than 1% from 0°C to 50°C.

f. Quality: The Q of the inductor shall be greater than 40 at a frequency of 200 kilocycles.

g. Self Resonant Frequency: The inductor shall resonate with its distributive capacitance at a frequency greater than 2 megacycles.

h. All inductors will be encased in a low-loss magnetic shielding material.

3.4.2.3 Inductor Switching Relays

a. Contact Voltage: Open contacts shall not break down at 600 volts.

b. Contact Current: Current carrying capacity of relay contacts shall be 1 ampere. Relays shall be switched cold.

c. Contact Capacitance: Capacity between open contacts shall not be more than 0.1 uuf.

d. Actuating Coil: The actuating of each relay shall operate from 26.5 vdc.

3.4.2.4 Leads: All leads between inductors and relays and leads to output terminals shall be of minimum length.

Appendix 21

Programmable Capacitive Load

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable capacitive load. This device is capable of presenting various capacitive loadings to a unit under test.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational, environmental and life requirements designated herein.

3.2.1 Service Life: 10,000 hrs. min.

3.3 Design

3.3.1 Capacitive Load: The capacitive load shall have capacitive values from 9 ufd to 10 uuf. The capacitive load shall be made up of 6 decade capacitive loads. All decades capacitive loads shall be connected in parallel.

3.3.2 Decade Capacitive Loads: Each decade capacitive load shall consist of four capacitors with one terminal connected to a common buss. The buss will lead to an output terminal. The remaining terminal of each capacitor will go to a relay contact. The value of the four capacitors will be 1, 2, 4, and 8 times the decade multiplier. The decade multiplier will range in values from 10^{-6} farads through 10^{-11} farads. If values do not correspond to RETMA standards the nearest standard value, within the capacitor tolerance defined below, will be used .

3.3.3 Relays: A S.p.s.t. relay contact is connected to each capacitor. The other end of the relay contacts are connected to a common buss which leads to the other output terminal.

3.4 Detail Performance Requirements

3.4.1 General

3.4.1.1 Output: Any value of capacitance from 9 ufd to .001 ufd to three significant digits can be presented across the output terminals. Values of capacitance from 100 uuf to 990uufd will be available to two significant digits and values of capacitance from 10 uuf to 90uuf will be available to one significant digit.

3.4.1.2 Programming: All programming will be done by applying externally supplied d.c. levels to the programmable capacitive load control lines.

a. Significant Digits: 12 control lines will be used to program the three significant digits of the capacitor value.

b. Capacitance multiplier: 4 control lines will be used to program the capacitance multiplier

c. Programming Time: The maximum time required to change from one value of capacitance to another shall not exceed 50 milliseconds.

d. Program Memory: Control relays and circuits shall not utilize latch up circuits requiring external unlatch commands.

3.4.2 Capacitors

3.4.2.1 Capacitors for the 10^{-6} farad decade.

a. Working Voltage: 600 V dc max.

b. Power Factor: Power factor of each capacitor will be 1% or less.

c. Tolerance: Values of capacitors will not vary more than 5% from the nominal value.

d. Temperature Coefficient: Change in capacitance due to temperature change shall not increase more than 0.05% per degree centigrade increase in temperature.

3.4.2.2 Capacitors for the 10^{-7} and 10^{-8} farad decades.

a. Working Voltage: 600 vdc

b. Power Factor: Power factor of each capacitor will be less than 0.1%.

c. Tolerance: Values of capacitors will not vary more than 1% from the nominal value.

d. Temperature Coefficient: Change in capacitance due to temperature change shall not decrease more than .015% per degree centigrade increase in temperature.

3.4.2.3 Capacitors for the 10^{-9}, 10^{-10}, and 10^{-11} farad decades.

a. Working Voltage: 500 vdc

b. Quality: The Q of each capacitor shall not be less than 1500 at 1 M.C. except the 10, 20, 40, and 80 uuf capacitors which shall not have a Q less than 500.

c. Tolerance: Values of capacitors will not vary more than 1% from the nominal value.

d. Temperature Coefficient: Change in capacitance due to temperature change shall not increase by more than .02% per degree centigrade increase in temperature.

3.4.2.4 Capacitor Switching Relays.

a. Contact Voltage: Open contacts shall not break down at 600 volts.

b. Contact Current: Current carrying capacity of relay contacts shall be 1 ampere. Relays shall be switched cold.

c. Contact Capacitance: Capacity between open contacts shall not be more than 0.1 uuf.

d. Actuating Coil: The actuating coil of each relay shall operate from 26.5 vdc.

3.4.2.5 Stray Capacitance: Capacitance between output terminals of the capacitive load shall not be greater than 3 uuf with all relay contacts in an open position.

3.4.2.6 Leads: All leads between capacitors and relays and leads to output terminals shall be of minimum length.

Appendix 22

Purchase Description

Programmable Impedance Meter

1. Scope

This Purchase Description covers the detailed requirements for a programmable impedance measuring device (impedance meter).

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours minimum

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 General

3.4.1.1 Power Requirements: 105-125 V AC, 50 - 420 cycles/second, single phase

3.4.1.2 Output Measured Value:

a. Capacitance Measurements - Output shall be capacity value in 3 digit Binary Coded Decimal (8-4-2-1).

b. Inductance Measurements - Output shall be inductance value in 3 digit Binary Coded Decimal (8-4-2-1).

c. Complex Impedance - Output shall be resistance value in 3 digit Binary Coded Decimal (8-4-2-1) and inductance or capacitance in 3 digit Binary Coded Decimal (8-4-2-1).

3.4.1.3 Output Signal Levels:

Logical "0" = DC voltage other than 0 volts DC, 6.8 K impedance.

Logical "1" = DC voltage other than logical "0".

3.4.1.4 Auxiliary Outputs: Output signals shall be provided for:

a. R, and L or C Indication when measuring complex impedance.

b. End of Conversion - Standard logic levels.

c. Overrange Indication - Standard logic levels.

3.4.1.5 Load Impedance: Measured value and auxiliary outputs shall be capable of driving a 3.9 K ohm resistive load connected between the output and -12 volts.

3.4.1.6 Programming: All programming will be done by applying externally supplied DC levels to the impedance meter control lines.

a. Type of Measurement Programming: 6 control lines will be used to program type of measurement.

Types of Measurements are:

1. Capacitance
2. Inductance
3. Series RC
4. Parallel RC
5. Series RL
6. Parallel RL

b. Programming Time: The maximum time to change from a given function and range to a new function and range shall not exceed 25 milliseconds.

c. Program Memory: Range and function control relays shall not utilize latch up circuits requiring external unlatch commands. A programmed range and function shall remain set up only while the appropriate control lines are held at the most positive programming voltage level with respect to common. When a control line drops to the most negative programming voltage, its corresponding relay or relays shall be deenergized.

3.4.1.7 Range Switching Time: Equal to or less than 25 milliseconds.

3.4.1.8 Standard References: The impedance meter shall include R, L, and C standards compatible with measurement accuracies specified. Calibration controls are needed and these must be easily accessible. Provision shall be made for calibration checks for all type measurements listed in 3.4.1.6 (a).

3.4.1.9 Warm-up Time: 45 seconds maximum.

3.4.1.10 Trigger: An external signal command results in making one conversion or measurement. Trigger requirements: a positive going pulse or step at standard logic levels with a rise time 1 microsecond or less.

3.4.1.11 Readouts: No readouts or readout driving stages are required.

3.4.1.12 Impedance Meter Oscillator: All oscillator signals required by the impedance meter shall be self contained.

3.4.2 Capacitance Measurements:

3.4.2.1 Capacitance Measurement Ranges:

a. 10 uufd - 100 uufd

b. 100 uufd - 1000 uufd

c. .001 ufd - .01 ufd

d. .01 ufd - .1 ufd

e. .1 ufd - 1 ufd

f. 1 ufd - 10 ufd

g. 10 ufd - 100 ufd

h. 100 ufd - 1000 ufd

3.4.2.2 Capacitance Measurement Accuracy:

Range a: ± 10% of measurement ± 1 uufd
Ranges b, c, d, e: ± 5% of measurement
Range f, g: ± 2% of measurement
Range h: ± 5% of measurement

3.4.3 Inductance Measurements:

3.4.3.1 Inductance Measurement Ranges:

a. 10 uh - 100 uh

b. 100 uh - 1000 uh

c. .001 henry - .01 henry

d. .01 henry - .1 henry

e. .1 henry - 1 henry

f. 1 henry - 10 henries

g. 10 henries - 100 henries

3.4.3.2 Inductance Measurement Accuracy:

Range a: ± 15% of measurement
Ranges b, c: ± 10% "
Ranges d,e: ± 5% "
Ranges f, g ± 2% "

3.4.4 Complex Impedance Measurement:

3.4.4.1 RC Combinations: The impedance meter shall be capable of impedance measurements upon circuits involving series or parallel combinations of resistance and capacitance.

3.4.4.1.1 Complex Impedance Component Ranges in RC Circuits

a. Capacitance range: 10 uufd to 100 ufd.

b. Resistance ranges:

1. 100 ohms - 1000 ohms

2. 1 K " - 10 K "

3. 10 K " - 100 K "

4. 100 K " - 1 Meg "

5. 1 Meg " - 5 Meg "

3.4.4.1.2 Complex Impedance Measurement Accuracy for RC Circuits:

a. For Capacitance range of 10 uufd - 100 uufd, accuracy shall be ± 20% for all above resistance ranges.

b. For Capacitances range of 100 uufd - 100 ufd, accuracy shall be ± 5% for resistance ranges 1, 4, 5 and ± 2% for resistance ranges 2, 3.

3.4.4.2 RL Combinations

The impedance meter shall be capable of measurements upon circuits involving series or parallel combinations of inductance and resistance.

3.4.4.2.1 Complex Impedance Component Ranges in RL Circuits:

a. Inductance range: 10 u henries to 5 henries.

b. Resistance ranges:

1.	5 ohms	-	10 ohms
2.	10 ohms	-	100 ohms
3.	100 ohms	-	1 K "
4.	1 K "	-	10 K "
5.	10 K "	-	100 K "
6.	100 K "	-	1 Meg "

3.4.4.2.2 Complex Impedance Measurement Accuracy for RL Circuits:

a. For Inductance ranges of 10 uh - 1 mh, accuracy shall be ± 20% for all above resistance ranges.

b. For Inductance range of 1 mh - 5 henries, accuracy shall be ± 15% for resistance range 1, ± 10% for resistance range 2, ± 5% for resistance ranges 3 and 6, ± 2% for resistance ranges 4 and 5.

Appendix 23

Purchase Description

Programmable Digital Multimeter

1. Scope

1.1 This purchase description covers the detailed requirements for a programmable digital multimeter. This instrument is capable of AC and DC voltage measurement, resistance measurement, and high speed analog to digital conversion.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational, environmental and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. Calibration controls and self triggering switch shall be provided. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 General

3.4.1.1 Output measured value: 3 digit binary coded decimal (8-4-2-1).

3.4.1.2 Output signal levels: Logical "0" = DC voltage other than 0 VDC 6.8 K impedance

Logical "1" = DC voltage other than logical "0".

3.4.1.3 Auxiliary Outputs: Auxiliary output signals shall be provided for:

a. Polarity Indication: Positive polarity = Logical "1"
Negative polarity = Logical "0"

b. End of Conversion: Std logic levels (different than 0 VDC)

Polarity optional

c. Overload Indication: Std logic levels; polarity optional

3.4.1.4 Load Impedance: Measured value and auxiliary outputs shall be capable of driving a 3.9 K ohm resistive load connected between the output and -12 volts.

3.4.1.5 Programming: All programming will be done by applying externally supplied DC levels to the digital multimeter control lines.

a. Type of measurement programming: 3 control lines will used to program type of measurement.

Type of measurements are:

(1) DC voltage
(2) AC voltage rms
(3) Ohms

b. Range: Ranges for the DC and AC voltage signal input channels will be programmed by means of four range control lines for voltage ranges of .999, 9.99, 99.9, 999 volts respectively.

c. Programming Time: the maximum time required to change from a given function and range to a new function and range shall not exceed 25 milliseconds.

d. Program Memory: Range and function control relays shall not utilize latch up circuits requiring external unlatch commands. A programmed range and function shall remain set up only while the appropriate control lines are held at the most positive programming voltage level with respect to common. When a control line drops to the most negative programming voltage, it's corresponding relay, or relays will return to the de-energized state.

3.4.1.6 Range Switching Time: The range switching time shall be equal or smaller than 25 msec.

3.4.1.7 Standard References: The multimeter shall include a DC voltage calibration standard. Calibration controls are needed and these have to be easily accessible. Provision shall be made for a calibration check in both AC and DC modes.

3.4.1.8 Warm Up Time: 45 sec. maximum

3.4.1.9 Trigger: An external signal command results in making one conversion. Signal requirement: a positive going pulse or step with a rise time 1 microsecond or less.

3.4.1.10 Readouts: No visual readouts or visual readout driving stages are required.

3.4.1.11 Settling Time: The settling time shall be defined as the time interval required for the multimeter input amplifier to stablize to within 0.1% of the DC voltage to be measured after application of the voltage to the multimeter input terminals. The settling time shall not exceed 20 milliseconds for a step function of 100 volts DC with a generator source resistance of 10 megohms.

3.4.2 DC Voltage

3.4.2.1 Ranges: (Full Scale)

a. .999 VDC
b. 9.99 VDC
c. 99.9 VDC
d. 999 VDC

Note: Maximum voltage input will be limited to 500 VDC.

3.4.2.2 Input Impedance: 10 megohms minimum

3.4.2.3 Input Polarity: Positive or negative with respect to common. Polarity shall be automatically sensed.

3.4.2.4 Accuracy: $\pm$0.5 millivolt from 0 to .1 volts and .1% of full scale from .1 volts to 500 volts at 27°C. (TC = $\pm$5 ppm/$^\circ$C from 27°).

3.4.2.5 Digitizing Rate: 1000 continuous conversions per second, minimum.

3.4.3 AC Voltage

3.4.3.1 Ranges: (Full Scale)

a. .999 VRMS
b. 9.99 VRMS
c. 99.9 VRMS
d. 999 VRMS

Note: Maximum voltage input will be limited to 500 VRMS.

3.4.3.2 **Input Impedance**: 0.1 megohm minimum in the 10 cps to 10 KC range.

3.4.3.3 **Input Frequency Range**: 10 cps to 10 KC.

3.4.3.4 **Accuracy**: $\pm$.5 millivolt from 0 to .1 volts and .1% of full scale from .1 volts to 500 volts over a frequency range of 10 cps to 10 KC at 27°C (TC = $\pm$5 ppm/°C from 27°).

3.4.3.5 **Measurement Rate**: (Rectifying Rate and Digitizing Rate): Conversion shall be complete at the end of 10 cycles of input signal, plus conversion time at any frequency within the range of 10 cps to 10 KC.

3.4.4 **Ohmmeter**

3.4.4.1 **Ranges**: (full scale)

a. 9.99
b. 99.9
c. 999
d. 999×10^1
e. 999×10^2
f. 999×10^3
g. 999×10^4

3.4.4.2 **Accuracy**: $\pm$.5% of maximum range measurement from .999 ohm to 9.99 ohm. $\pm$.1% of maximum range measurement from 9.99 ohms to 9.99 megohms.

3.4.4.3 **Power Dissipation**: Not greater than .1 watt in resistance under test.

Appendix 24

Purchase Description

Programmable Time Interval and Frequency Meter

1. Scope

1.1 This purchase description covers the detail requirements for a 10 megacycle programmable time interval and frequency meter.

2. Applicable Documents (MDME-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDME-PD-63 apply as requirements of this purchase description. When two purchase descriptions conflict, this purchase description shall govern.

3.2 Reliability

3.2.1 Service Life: 10,000 hours min.

3.3 Detail Performance Requirements

3.3.1 General

3.3.1.1 Output Measured Value: 7 digit decimal readout

3.3.1.2 Programming: All programming will be done with 8-4-2-1 BCD code by DC levels supplied to internal control lines.

a. Functions to be programmed

Power on-off

Function: frequency
time interval
period

Input Attenuation:
.1 V - 1.0 V
1.0 V - 10 V
10 V - 100 V
100 V - 500 V

Input Polarity:
Input #1 + or -
Input #2 + or -

Input #1 used for frequency, period
Input #2 used for time interval together with input #1

Frequency Range: 99.9 cps to 9.99 MC/S

Time interval/period: 0.9 usec to 999 sec

3.3.1.3 Programming Time: The maximum time required to change from a given function and range to a new function and range shall not exceed 25 milliseconds.

3.3.1.4 Range switching time shall be less than 25 milliseconds.

3.3.1.5 Warm-Up Time: 30 sec. max.

3.3.1.6 Readouts: 7 decimal digits capable of remote readout.

3.4.2 Frequency

3.4.2.1 Ranges: 99.9 cps to 9.99 M cps in decade steps.

3.4.2.2 Input Impedance: 1 meg shunted by not more than 20 uuf.

3.4.2.3 Input Characteristics: Sine wave or pulse, 10 MV to 500 V, plus or minus polarity.

3.4.2.4 Accuracy: ± 1 count of input signal and $\pm$osc. stability of ± 3 parts in 10^7 per week.

3.4.3 Time Interval

3.4.3.1 Ranges: .999 usec to 999 sec in decade steps.

3.4.3.2 Input Impedance: 1 meg shunted by not more than 20uuf.

3.4.3.3 Input Characteristics: Pulse or sine wave below 100 cps; 10 MV to 500 V plus or minus polarity for separate start and stop channels. Plus or minus polarity for one channel control.

3.4.3.4 Accuracy: same as 3.4.2.4

Appendix 25
Purchase Description

Programmable Radio Frequency Average Power Indicator and Reflectometer

1. Scope

1.1 Scope: This specification covers the general and detail requirements for a programmable thermistor bridge R. F. average power indicator and reflectometer in the 2.0 MC to 12.5 KMC range.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 General:

3.4.1.1 Power Range: -20 dbm to +10 dbm full scale in 4 ranges without external attenuator. +10 to +40 dbm and +40 to +70 dbm with external attenuators.

3.4.1.2 Frequency Range: 2 MC/s to 12.5 KMC/s with coaxial and waveguide thermistor mounts.

3.4.1.3 Accuracy: $\pm$3% of full scale

3.4.1.4 Thermistor Mount SWR: 1.5 maximum.

3.4.1.5 Outputs:

(1) Voltage proportional to incident power.
(2) Voltage proportional to reflected power.
(3) Voltage proportional to VSWR.

3.4.2 Programming:

3.4.2.1 Program Code: 8-4-2-1 BCD.

3.4.2.2 Programming Devices: Solid State and electromechanical switches.

3.4.2.3 Programmed Functions:

(1) External line supply.
(2) Power Range.

3.4.2.4 Programming Time: 3 seconds maximum.

3.4.2.5 Warm-up Time: 5 minutes maximum.

3.4.2.6 Input Power: 105 to 125 VAC, 55 to 420 cps single phase. Neutral floating and isolated.

Appendix 26
Purchase Description

Waveform Analyzer

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable waveform analyzer. This instrument is capable of measuring peak amplitude, width, rise time and fall time of a recurrent pulse waveform.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational, and life requirements designated herein.

3.2.1 Service Life: 1000 hrs. min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. Calibration controls and self triggering switch shall be provided. All other functions are to be performed from a remote source.

3.3.2 Indicators: Remote indicators shall be provided

3.4 Detail Performance Requirements

3.4.1 General

3.4.1.1 Output Measured Value: 3 digit Binary Coded Decimal (-8-4-2-1).

3.4.1.2 Output Signal Levels: Logical "0" = DC voltage other than 0 VDC 6.8 K impedance

Logical "1" = DC voltage other than logical "0"

3.4.1.3 Auxiliary Outputs: Auxiliary output signals shall be provided for:

a. End of Conversion:

Std logic levels:

polarity optional

b. Overload Indication:

Std logic levels

polarity optional

c. Outputs for Maintenance Purposes:

optional

3.4.1.4 Load Impedance: Measured value and auxiliary outputs shall be capable of driving a 3.9 K ohm resistive load connected between the output and -12 volts.

3.4.1.5 Programming: All programming will be done by applying externally supplied D.C. levels to the digital multimeter control lines.

a. Type of Measurement Programming: 4 control lines will be used to program type of measurement. Type of measurements are:

1. peak pulse amplitude
2. pulse width
3. rise time
4. fall time

b. Ranges: Ranges for the signal input channel for peak amplitude measurement will be programmed by means of four range control lines 1 through 4 for peak voltage ranges of .999, 9.99, 99.9, and 999 respectively.

c. Polarity: One control line will be used to program input pulse polarity.

d. Time: Ranges for pulse width, rise time, fall time will be programmed by means of 7 control lines for time ranges 1 through 7 of .05 usec - .1 usec., .1 usec - 1 usec., 1 usec - 10 usec., 10 usec - 100 usec., 100 usec. - 1 msec., 1 msec. - 10 msec., 10 msec. - 100 msec., respectively.

e. Amplitude at which pulse width is measured shall be programmed by means of 3 control lines for measurement at 10%, 50%, or 90% of peak amplitude, respectively.

f. Programming Time: The maximum time required to change from a given function and range to a new function and range shall not exceed 25 milli-seconds.

g. Program Memory: Range and function control relays shall not utilize latch up circuits requiring external unlatch commands. A programmed range and function shall remain set up only while the appropriate control lines are held at the most positive programming voltage level with respect to common. When a control line drops to the most negative programmed voltage, it's corresponding relay, or relays will return to the de-energized state.

3.4.1.6 Range Switching Time: The range switching time shall be equal or smaller than 25 usec.

3.4.1.7 Standard References: The waveform analyzer shall include a standard for peak amplitude measurement calibration and a standard for time base calibration. Provision shall be made for calibration checks in all measurement modes.

3.4.1.8 Warm-up Time: 45 seconds maximum

3.4.1.9 Pulse Repetition Rate Ranges: 2 pps to 83,300 pps
Minimum duty cycle .0036% at 0.2 usec pulse width.

3.4.1.10 Readouts: No readouts or readout driving stages are required.

3.4.2 Pulse Peak Amplitude Measurement

3.4.2.1 Ranges (Full Scale)

a. .999 volts peak

b. 9.99

c. 99.9

d. 999

Note: Minimum input voltage .5 V peak
Maximum input voltage 400 V peak.

3.4.2.2 Input Impedance: 50 ohms

3.4.2.3 Input Polarity: Positive or negative with respect to common.

3.4.2.4 Accuracy:

0.5 V	-	9.99V	± 3%
10 V	-	99.9 V	± 5%
100 V	-	400 V	± 8%

3.4.3 Pulse Width Measurement

3.4.3.1 Pulse Width Ranges:

a. 0.1 usec - 1.0 usec

b. 1.0 usec - 10 usec

c. 10 usec - 100 usec

d. 100 usec - 1 msec

e. 1 msec - 10 msec

f. 10 msec - 100 msec.

3.4.3.2 Pulse Width Accuracy: ± 3% of full scale range.

3.4.3.3 Amplitude at which pulse width is measured Programmable, 10%, 50% or 90% of pulse peak amplitude.

3.4.4 Rise Time

3.4.4.1 Rise Time Ranges:

a. .05 usec - 0.1 usec

b. 0.1 usec - 1 usec

c. 1 usec - 10 usec

d. 10 usec - 100 usec

e. 100 usec - 1 msec

f. 10 msec - 100 msec

3.4.4.2 Rise Time Measurement: ± 3% of full scale ± .01 usec.

3.4.4.3 Rise Time shall be measured from the 10% peak amplitude point to the 90% peak amplitude point of a given waveform.

3.4.5 Fall Time

3.4.5.1 Fall Time Ranges:

a. .05 usec - 0.1 usec

b. 0.1 usec - 1 usec

c. 1 usec - 10 usec

d. 10 usec - 100 usec

e. 100 usec - 1 msec

f. 10 msec - 100 msec.

3.4.5.2 Fall time measurement Accuracy: ± 3% of full scale ± .01 usec.

3.4.5.3 Fall time shall be measured from the 90% peak amplitude point to the 10% peak amplitude point of a given waveform.

Appendix 27
Purchase Description

Programmable Spectrum Analyzer, L Band

1. Scope

1.1 This purchase description covers the general and detail requirements for a programmable unit operating in the "L" band which will give a voltage output proportional to the RF energy in a given narrow band.

2. Applicable Documents (MDME-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDME-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict this purchase description shall govern.

3.2 Reliability

3.2.1 Service Life: 10,000 hours min.

3.3 Detail Performance Requirements

3.3.1 Output: A DC voltage proportional to signal strength.

3.3.2 Frequency Range: 962 to 1213 MC.
3.3.3 Frequency Stability: ±5 KC
3.3.4 Sensitivity: -70 dbm

3.3.5 Bandwith: .51 MC ±10 KC at 3 db and .75 MC at 50 db may be centered on a selected frequency in the band or ±.5 MC ±.8 MC ±1.0 MC and ±1.75 MC around selected frequency. Gain must not vary more than .5 db at any of the above frequencies around selected frequency.

3.3.6 Local Oscillators: First local osc. shall be crystal controlled and have at least 6 selectable frequencies. There shall be provision for the use of an external signal generator as a local osc. Second local osc. shall be crystal controlled and have nine selectable frequencies corresponding to dispersion frequencies mentioned in 3.3.5.

3.3.7 Attenuation: 0 to 60 db in steps of 5 db.

3.3.8 Input Impedance: 50 ohms

3.4 Programming

3.4.1 Code: All numerical values shall be expressed in the 8-4-2-1 BCD code (with the most significant digit allowed values up to 15).

3.4.2 Program Command: Program information shall be received as logic levels on a "message bus", on which the information content shall not change more than once per millisecond.

3.4.3 Programming Time: The maximum time required to change from a given program to a new program shall not exceed 6 milliseconds per address plus 10 milliseconds for relaying operation.

3.4.4 Functions to be programmed:

a. Attenuation shall be programmed to go from 0 to 60 db in steps of 5 db.

b. Center frequency shall be programmed to select one of 6 crystals or an external osc.

c. Dispersion shall be programmed to select one of 9 crystals to give center frequency and spectrum points at + or - .5 MC, + or - .8 MC, + or - 1 MC, and + or - 1.75 MC from center frequency.

Appendix 28

Purchase Description

Programmable Spectrum Analyzer 1.2 - 12.4 KMC

1. Scope

    1.1 This Purchase Description covers the detailed requirements for a programmable spectrum analyzer in the 1.2 to 12.4 KMC range.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

    3.1 The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

    3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

        3.2.1 Service Life: 10,000 hours min.

    3.3 Design

        3.3.1 Controls: An auxiliary on-off switch and a manual dispersion selection switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

    3.4 Detail Performance Requirements

        3.4.1 General

            3.4.1.1 Power Requirements: 105-125 V AC 55 to 420 cps single phase.

            3.4.1.2 Sensitivity: 20 dbm

            3.4.1.4 Accuracy of frequency at start of sweep ± .01% of programmed value.

            3.4.1.5 Sweep Frequency: 0.1 to 30 cps.

            3.4.1.6 Output: 0 - 100 V DC

            3.4.1.7 Programming: All programming will be done by applying externally supplied DC levels to the Spectrum Analyzer control lines.

                3.4.1.7.1 Functions Programmed

3.4.1.7.1.1 Frequency at start of sweep shall be programmable in 10 MC steps.

3.4.1.7.1.2 Sweep rate programmable at .1 cps, 1 cps, 10 cps, 30 cps.

3.4.1.7.1.3 Dispersion programmable 10 MC, 50 MC and 200 MC.

3.4.1.7.2 Program Code: 8-4-2-1 BCD.

Appendix 29

Purchase Description

Programmable Peak Power Meter

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable peak power meter. This instrument is capable of measuring the peak power of a pulsed R.F. system.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. Calibration controls shall be provided. All other functions are to be performed from a remote source.

3.4 Detailed performance requirement

3.4.1 General

3.4.1.1 Output: 10 volts D.C. min. across 500 K ohm load impedance for max. peak power reading on scale chosen. Voltage shall be directly proportional to peak power input.

3.4.1.2 Programming: All programming will be done by applying externally supplied D.C. levels to control lines.

3.4.1.2.1 Functions Programmed - Power Range:

0 - 30 milliwatts
0 - 100 milliwatts
0 - 300 milliwatts

3.4.1.2.2 Programming time shall not exceed 25 milliseconds.

3.4.1.3 Power Requirements: 105-125 volts single phase 50 to 420 cps.

3.4.1.4 Warmup time shall not exceed 45 seconds.

3.4.1.5 Frequency Range: 400 MC to 18 KMC with suitable bolometer mounts which are to be supplied with meter.

3.4.1.6 Accuracy: ± 10% overall.

3.4.1.7 Pulse Repetition Rate: 50 to 5000 pps.

3.4.1.8 Pulse Width: .25 to 10 usec.

3.4.1.9 Pulse Rise Time: .15usec.

3.4.1.10 Bolometer mounts must be capable of operation up to 10 feet from meter.

Appendix 30

Purchase Description

Programmable Static Pressure Generator

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable static pressure generator. This instrument is capable of supplying air or an inert gas at programmable constant pressures.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.3.2 Indicators: Remote indicators shall be provided.

3.4 Detailed performance requirements

3.4.1 General

3.4.1.1 Output: Pressures from 2.50 PSIA to 14.5 PSIA in .25 psi steps.

3.4.1.2 Max. volume in which pressure must be attained and maintained: 0.1 cu. ft.

3.4.1.3 Accuracy: Output pressure shall be within ±1% of programmed pressure.

3.4.1.4 Programming: All programming will be done by applying externally supplied DC levels to the control lines.

Programmable Static Pressure Generator (Contd)

3.4.1.4.1 Functions Programmed: Output pressures in .25 psi steps from 2.50 psia to 14.5 psia minimum range.

3.4.1.4.2 Programmed pressure ±1% must be reached within 2 sec.

3.4.1.5 Power Requirements: 105-125 Volts AC single phase 55 to 400 cycles

Appendix 31

Purchase Description

Programmable Spectrum Analyzer 12.4 - 18 KMC

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable spectrum analyzer in the 12.4 KMC to 18 KMC range.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch and a manual dispersion selection switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 General

3.4.1.1 Power Requirements: 105 - 125 V AC 55 to 420 cps single phase.

3.4.1.2 Tuning Range: 12 - 18 KMC

3.4.1.3 Dispersions: 10MC, 50MC, 200MC.

3.4.1.4 Accuracy of frequency at start of sweep $\pm$ .01% of programmed value.

3.4.1.5 Sweep Frequency: 0.1 to 30 cps.

3.4.1.6 Output: 0 - 100 V DC.

3.4.1.7 Programming: All programming will be done by applying externally supplied DC levels to the Spectrum Analyzer control lines.

3.4.1.7.1 Functions Programmed

3.4.1.7.1.1 Frequency at start of sweep shall be programmable in 10 MC steps.

3.4.1.7.1.2 Sweep rate programmable at .1 cps, 1 cps, 10 cps, 30 cps.

3.4.1.7.1.3 Dispersion programmable - 10 MC, 50 MC and 200 MC.

3.4.1.7.2 Program Code: 8-4-2-1 BCD

Appendix 32

Purchase Description

Programmable Phase Meter

1. Scope

1.1 This Purchase Description covers the detailed requirement for a programmable phase meter.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location.

3.4 Detail Performance Requirement

3.4.1 General

3.4.1.1 Output: 10 volts D.C. minimum across - 500 K ohm load impedance for full scale meter reading. Output voltage shall be directly proportional to input phase angle.

3.4.1.2 Programming: All programming will be done by applying externally supplied DC levels to phase meter control lines.

a) Ranges: 0 - 12°, 0 - 36°, 0 - 90°, 0 - 180°. A switch shall be provided to add 180° to above.

b) Programming Time: Maximum time to change from one range to another 25 milliseconds.

3.4.1.3 Warmup Time: 45 sec. maximum

Programmable Phase Meter (Contd)

3.4.1.4 Power Requirements: 105-125 volts single phase 55 to 420 cycles.

3.4.1.5 Input

3.4.1.5.1 Frequency Range: 2 mc to 30 mc.

3.4.1.5.2 Amplitude: 1 volt or less for full scale reading on lowest degree scale. Input of up to 30 volts shall not affect reading.

3.4.1.5.3 Input Impedance: 20 uuf or less shunted by 1 megohm or more.

3.4.1.6 Accuracy: ± 1 degree absolute, 0.25 degree relative.

Appendix 33

Purchase Description

Programmable Amplitude Modulation Detector and Amplifier

1. Scope

   1.1 This Purchase Description covers the detailed requirements for a programmable amplitude modulation detector and amplifier. This instrument is capable of detecting amplitude modulation in the range of 0 to 20 KC from a carrier frequency of 400 cps to 30 MC.

2. Applicable Documents (MDME-PD-63)

3. Requirements

   3.1 General Purchase Description: The requirements of general purchase description No. MDME-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

   3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

      3.2.1 Service Life: 10,000 hours minimum.

   3.3 Design

      3.3.1 Controls: An auxiliary on-off switch shall be provided in accessible location. All other functions are to be performed from a remote source.

   3.4 Detail Performance Requirements

      3.4.1 General

         3.4.1.1 Input Carrier Frequency Range: 400 cps to 30 MC.

         3.4.1.2 Input Impedance: 1 megohm

         3.4.1.3 Modulation Range: 0 to 20 KC

         3.4.1.4 Input Signal Amplitude: 0.1 volt RMS minimum.

         3.4.1.5 Output Range: 0-10 volts RMS.

         3.4.1.6 Load Impedance: 600 ohms maximum loading

         3.4.1.7 Programming: All programming will be done by applying externally supplied DC levels to the modulation detector and amplifier control lines.

Programmable Amplitude Modulation Detector and Amplifier (Contd)

a. Functions Programmed:

1. Amplifier high frequency cutoff shall be programmable for 50 KC, 20 cps, 2 cps or 0.25 cps.

2. Input attenuation shall be programmable by factors of ten (X 10) and one hundred (X 100).

3. Amplifier gain shall be programmable by factors of unity (X 1) ten (X 10) and one hundred (X 100).

b. Programming Time: The maximum time required to change from a given cutoff characteristic and gain or attenuation to a new cutoff characteristic and gain or attenuation shallnot exceed 25 milliseconds.

c. Program Memory: Control relays shall not utilize latch up circuits requiring external unlatch commands. A programmed function shall remain set up only while the appropriate control lines are held at the most positive programming voltage level with respect to common. When a control line drops to the most negative programming voltage, its corresponding relay or relays will de-energize.

3.4.1.8 Warm-up Time: 45 seconds maximum

Appendix 34

Purchase Description

Programmable D.C. Power Supply 0.1 - 35 V

1. Scope

1.1 Scope: This specification covers the general and detail requirements for a programmable, all solid state, D.C. power supply in the 0.1 - 35 V range.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 Power Requirements: 105-125 VAC, 55-420 cps, single phase.

3.4.2 Output Voltage: 0.1 - 35 volts, positive or negative polarity, in 0.1V steps, with programming accuracies listed below:
0.1 - 5V $\pm$1%
5V-35V $\pm$ 50mv

3.4.3 Output Current:

0 - 1V	150 ma. max.
1V - 35V	2.5 amps max.

3.4.4 Line Regulation: A step input change in line voltage (-10% to +10% of nominal) will not cause an output voltage change of more than 10 mv while delivering 1 volt, or more than 50 mv while delivering 35 volts.

3.4.5 Load Regulation: A no load to full load or full load to no load step change will not cause an output voltage change of more than 10 mv while delivering 1 volt, nor more than 50 mv when delivering 35 volts, within 50 microseconds after application of such a step change.

3.4.6 Transient response to simultaneous line and load variations: The output voltage shall not change more than 10 mv while delivering one volt nor more than 50 mv while delivering 35 volts for any combination of line voltage variations (±10% about nominal) and load changes of ±10%.

3.4.7 Ripple: The ripple voltage in the output shall not exceed 4 mv peak to peak under all combinations of input voltage and load variation.

3.4.8 Stability: The output voltage shall not vary more than ±1% or 50 mv, whichever is less, over an eight hour period.

3.4.9 Output Impedance: Less than .1 ohm from D.C. to 100 KC.

3.4.10 Metering: A meter shall be provided with a -35V to +35V scale (0 volt mid-point). The accuracy of the meter shall be ±1% full scale.

3.4.11 Short Circuit Protection: Protection shall be provided against short circuiting the power supply.

3.4.12 Output Voltage Terminals: Both terminals shall be floating with respect to ground. With one terminal considered as reference the other's polarity shall be programmable (+) or (-) with respect to the reference.

3.4.13 Programming: All programming will be done by applying externally supplied D.C. levels to the power supply control lines.

3.4.13.1 Control Lines: The output voltage shall be programmed by means of ten control lines weighted as follows:

1.	0.1V
2.	0.2V
3.	0.4V
4.	0.8V
5.	1.0V
6.	2.0V
7.	4.0V
8.	8.0V
9.	10.0V
10.	20.0V

Ranging information and selection, if necessary, shall be obtained from these BCD inputs and appropriate logic circuitry internal to the supply. Lines 1-10 will carry pure BCD information (8-4-2-1). A line will also be provided to program polarity.

3.4.13.2 Programming Time: The maximum time required to change from a given polarity and range to a new polarity and range shall not exceed 50 milliseconds.

3.4.13.3 Transient Behavior During Programming: When programming a more positive voltage than the previously programmed level, the output voltage waveform shall be continuous and the transient voltage output during programming shall not be less positive than the previous level or exceed the newly programmed level by more than 1%.

When programming a voltage less positive than the previously programmed level, the output voltage during programming shall be continuous and the transient voltage output during programming shall not exceed the previous level nor fall below the newly programmed level by more than 1%.

3.4.14 Switching Time: 50 milliseconds maximum to be within the regulation specified.

3.4.15 Warmup Time: The time required after application of primary power for the output voltage to be programmable with the accuracy specified in paragraph 3.4.2 shall not exceed 45 seconds.

Appendix 35

Purchase Description

Programmable D.C. Power Supply 22-32V D.C.

1. Scope

1.1 Scope: This specification covers the general and detail requirements for a programmable, all solid state, D.C. power supply in the 22-32V range.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 Power Requirements: 105-125 VAC, 55-420 CPS, single phase.

3.4.2 Output Voltage: 22-32 volts, positive or negative polarity, in 0.1v steps, programming accuracy $\pm$ 50 mv.

3.4.3 Output Current: 27 amps max.

3.4.4 Line Regulation: A step input change in line voltage (-10% to +10% of nominal) will not cause an output voltage change of more than 50 mv while delivering 27 volts.

3.4.5 Load Regulation: A no load to full load or full load to no load step change will not cause an output voltage change of more than 50 mv while delivering 27 volts, within 50 microseconds after application of such a step change.

3.4.6 Transient Response to Simultaneous Line and Load Variations: The output voltage shall not change more than 50 mv while delivering 27 volts for any combination of line voltage changes (±10% about nominal) and load changes of ±10%.

3.4.7 Ripple: The ripple voltage in the output shall not exceed 30 mv peak to peak under all combinations of input voltage and load variations.

3.4.8 Stability: The output voltage shall not vary more than 10 mv over an eight hour period.

3.4.9 Output Impedance: Less than .01 ohms from D.C. to 100 KC.

3.4.10 Metering: A meter shall be provided with a -32v to 32v scale (0 volt mid-point). The accuracy of the meter shall be ±1% of full scale.

3.4.11 Short Circuit Protection: Protection shall be provided against short circuiting the power supply.

3.4.12 Output Voltage Terminals: Both terminals shall be floating with respect to ground. With one terminal considered as reference the other's polarity shall be programmable (+) or (-) with respect to the reference.

3.4.13 Programming: All programming will be done by applying externally supplied DC levels to the power supply control lines.

3.4.13.1 Control Lines: The output voltage shall be programmed by means of ten control lines weighted as follows:

1.	0.1V	6.	2.0V
2.	0.2V	7.	4.0V
3.	0.4V	8.	8.0V
4.	0.8V	9.	10.0V
5.	1.0V	10.	20.0V

A line will also be provided to program polarity. Lines 1-10 will carry pure BCD information (8-4-2-1).

3.4.13.2 Programming Time: The maximum time required to change from a given polarity and range to a new polarity and range shall not exceed 50 milliseconds.

3.4.13.3 Transient Behavior During Programming: When programming a more positive voltage than the previously programmed level, the output voltage waveform shall be continuous and

3.4.13.3 Continued

the transient voltage output during programming shall not be less positive than the previous level or exceed the newly programmed level by more than 1%. When programming a voltage less positive than the previously programmed level, the output voltage during programming shall be continuous and the transient voltage output during programming shall not exceed the previous level nor fall below the newly programmed level by more than 1%.

3.4.14 Switching Time: 50 milliseconds maximum to be within the regulation specified.

3.4.15 Warmup Time: The time required after application of primary power for the output voltage to be programmable with the accuracy specified in paragraph 3.4.2 shall not exceed 45 seconds.

Appendix 36

Purchase Description

Programmable D.C. Power Supply 30-500V

1. Scope

1.1 Scope: This specification covers the general and detail requirements for a programmable D.C. power supply in the 30-500V range.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 Power Requirements: 105-125 VAC, 55-420 cps, single phase

3.4.2 Output Voltage: 30-200V in 1 volt steps
200-500V in 5 volt steps
Positive or negative polarity

Programming accuracy 30-500V ±0.5%

3.4.3 Output Current: 1 amp max.

3.4.4 Line Regulation: A step input change in line voltage (-10% to +10% of nominal) will not cause an output voltage change of more than 200 MV, while delivering 30-80 volts, or more than +.25% while delivering 80-500 volts.

3.4.5 Load Regulation: A no load to full load or full load to no load step change will not cause an output voltage change of more than 200 MV while delivering 30-80 volts, nor more than ±0.25% when delivering 80-500 volts, within 50 microseconds after application of such a step change.

3.4.6 Transient Response to simultaneous line and load variations: The output voltage shall not change more than 200 MV while delivering 30-80 volts nor more than ±0.25% while delivering 200-500 volts for any combination of line voltage variations (±10% about nominal) and load changes of ±10%.

3.4.7 Ripple: The ripple voltage in the output shall not exceed 10 MV peak to peak under all combinations of input voltage and load variation.

3.4.8 Stability: The output voltage shall not vary more than 100 MV over an eight hour period.

3.4.9 Output Impedance: Less than 1 ohm from D.C. to 100 KC.

3.4.10 Metering: A meter shall be provided with a 0-50V, 0-500V range. Range and polarity shall be automatically selected. The accuracy of the meter shall be ±1% of full scale.

3.4.11 Short Circuit Protection: Protection shall be provided against short circuiting the power supply.

3.4.12 Output Voltage Terminals: Both terminals shall be floating with respect to ground. With one terminal considered as reference the other's polarity shall be programmable (+) or (-) with respect to the reference.

3.4.13 Programming: All programming will be done by applying externally supplied D.C. levels to the power supply control lines.

3.4.13.1 Control Lines: The output voltage shall be programmed by means of eleven control lines weighted as follows:

1.	1 V	6.	20 V
2.	2 V	7.	40 V
3.	4 V	8.	80 V
4.	8 V	9.	100 V
5.	10 V	10.	200 V
		11.	400 V

Ranging information and selection, if necessary, shall be obtained from these BCD inputs and appropriate logic circuitry internal to the supply. Lines 1 - 11 will carry pure BCD information (8-4-2-1). A line will also be provided to program polarity.

3.4.13.2 Programming Time: The maximum time required to change from a given polarity and range to a new polarity and range shall not exceed 50 milliseconds.

3.4.13.3 Transient Behavior During Programming: When programming a more positive voltage than the previously programmed level, the output voltage waveform shall be continuous and the transient voltage output during programming shall not be less positive than the previous level or exceed the newly programmed level by more than 1%.

When programming a voltage less positive than the previously programmed level, the output voltage during programming shall be continuous and the transient voltage output during programming shall not exceed the previous level nor fall below the newly programmed level by more than 1%.

3.4.14 Switching Time: 50 milliseconds maximum to be within the regulation specified.

3.4.15 Warmup Time: The time required after application of primary power for the output voltage to be programmable with the accuracy specified in paragraph 3.4.2 shall not exceed 45 seconds.

Appendix 37
Purchase Description

Programmable D.C. Power Supply 500-6000 V D.C.

1. Scope

1.1 Scope: This specification covers the general and detail requirements for a programmable D. C. power supply in the 500-6000 V range.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 Power Requirements: 105 - 125 V A.C., 55 - 420 CPS, single phase.

3.4.2 Output Voltage: 500 - 6000V, pos. or neg. polarity in 50 volt steps.

Programming accuracy $\pm 1\%$

3.4.3 Output Current: 800 ma. to 1000 volts
250 ma. to 1000-6000 volts.

3.4.4 Line Regulation: A variation in input voltage ($\pm 10\%$ of nominal) will not cause an output voltage change of more than $\pm 0.5\%$.

3.4.5 Load Regulation: A variation of $\pm 10\%$ in the load will not cause an output voltage change of more than $\pm 1\%$.

3.4.6 Speed of Response: 2 seconds maximum.

3.4.7 Ripple: 1% R.M.S. over entire output voltage and current range.

3.4.8 Stability: The output voltage shall not vary more than 0.5% over an eight hour period.

3.4.9 Output Impedance: Less than 10 ohms from D.C. to 100 KC.

3.4.10 Metering: A three range meter shall be provided covering the entire output range. Meter accuracy ±2% full scale. The meter ranges shall be automatically switched.

3.4.11 Short Circuit Protection: Protection shall be provided against short circuiting the power supply.

3.4.12 Over Voltage Protection: Protection shall be provided against over voltage of more than 2% while programming.

3.4.13 Programming: All programming will be done by applying externally supplied D.C. levels to the power supply control lines.

3.4.13.1 Control Lines: The output voltage shall be programmable by means of eight control lines weighted as follows:

1. 50
2. 100
3. 200
4. 400
5. 800
6. 1000
7. 2000
8. 4000

Ranging information and selection, if necessary, shall be obtained from these BCD inputs and appropriate logic circuitry internal to the supply.

3.4.13.2 Programming Time: The maximum time required to change from a given range to a new range shall not exceed 25 milliseconds.

3.4.13.3 Transient Behavior During Programming: When programming a more positive voltage than the previously programmed level, the output voltage waveform shall be continuous and the transient voltage output during programming shall not be less positive than the previous level or exceed the newly programmed level by more than 2%. When programming a voltage less positive than the previously programmed level,

3.4.13.3 Continued

the output voltage during programming shall be continuous and the transient voltage output during programming shall not exceed the previous level nor fall below the newly programmed level by more than 2%.

3.4.14 Switching Time: 2 seconds to be within the regulation specified.

3.4.15 Warmup Time: The time required after application of primary power for the output voltage to be programmable with the accuracy specified in paragraph 3.4.2 shall not exceed 45 seconds.

Appendix 38

Purchase Description

Programmable Phase Referenced 400 C.P.S. A.C. Power Supply

1. Scope

1.1 Scope: This specification covers the general and detail requirements for a programmable phase referenced 400 C.P.S. A.C. power supply.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements:

3.4.1 Power Requirements: 105-125V A.C., 55-420 CPS, Single phase.

3.4.2 Output Voltage: Reference output 115V $\pm$1% 400 CPS $\pm$0.1%.
Phase shifted programmable output, 400 CPS.
0 - 1 volt RMS in 0.5 volt steps
1 - 30 volts RMS in 1 volt steps
115 volts RMS

Programming Accuracy 0-10V $\pm$ .1 volt
10-30V, 115V $\pm$1%

3.4.3 Phase Shift: Provision shall be included to shift the phase of the programmable output voltage by: (0, $\pm$ 30°, $\pm$90° or 180°) $\pm$ 1% accuracy
With respect to the phase of the 115V A.C. 400 cycle reference.

3.4.4 Distortion: Waveform distortion shall be less than 5%.

3.4.5 Output Current: Ref. output: 4.5 amp.

Programmable output:

0 - 1 volt	0.1 amp.
1V - 30 volt	3.5 amps.
115 volt	4.5 amp.

3.4.6 Static Regulation: A variation in input voltage (±10% of nominal) shall not cause an output voltage change of more than ± .1 volt in the 0-10V range nor more than ± 2% in the 10-30V, 115V ranges.

A no load to full load or full load to no load step change shall not cause an output voltage change of more than ± .2 volt in the 0-10V range nor more than ± 2% in the 10-30 volt, 115 volt ranges.

3.4.7 Speed of Response: Power supply shall be capable of covering 20% of the programmed range voltage within 1 sec.

3.4.8 Response to simultaneous line and load variations: The output voltage shall not change more than ± .2 volt in the 0-10V range nor more than ± 2% in the 10-30 volt, 115 volt range for any combination of line voltage changes (±10% of nominal) and load changes (±10%).

3.4.9 Output Impedance: Less than .5 ohms.

3.4.10 Metering: A meter shall be provided to cover the 0-30V range. The accuracy of the meter shall be ±1% of full scale. A visual indication, such as a light, shall indicate the 115 volt setting. The meter or light shall be automatically selected.

3.4.11 Short Circuit Protection: Provision to protect the power supply against short circuit shall be provided.

3.4.12 Programming: All programming will be done by applying externally supplied D.C. levels to the power supply control lines.

3.4.12.1 Control Lines: The output voltage shall be programmed by means of eight control lines weighted as follows:

1. 0.5V
2. 1.0
3. 2.0
4. 4.0
5. 8.0
6. 10.0
7. 20.0
8. 100.

Ranging information and selection, if necessary, shall be obtained from these inputs and appropriate logic circuitry internal to the supply. Phase shift will be programmed by three lines weighted as follows:

1. 0°, 180°
2. $\pm 30^\circ$
3. $\pm 90^\circ$

A logic zero level indicates either 0° or positive phase shift.
A logic one level indicates either 180° or negative phase shift.

3.4.12.2 Programming Time: The maximum time required to change from a given range, voltage and phase to a new range, voltage and phase shall not exceed 50 milliseconds.

3.4.12.3 Transient Behavior During Programming: When programming a higher voltage than the previously programmed level, the output voltage waveform shall be continuous and the transient voltage output during programming shall not be less than the previous level or exceed the newly programmed level by more than 3%. When programming a voltage less than the previously programmed level, the output voltage waveform during programming shall be continuous and the transient voltage output during programming shall not exceed the previous level nor fall below the newly programmed level by more than 3%.

3.4.13 Warmup Time: The time required after application of primary power for the output voltage to be programmable with the accuracy specified in paragraph 3.4.2 shall not exceed 45 seconds.

Appendix 39

Purchase Description

Programmable A.C. Power Supply 16-300 VAC

1. **Scope**

   1.1 Scope: This specification covers the general and detail requirements for a programmable A.C. power supply in the 16-300 VAC range.

2. **Applicable Documents** (MDNE-PD-63)

3. **Requirements**

   3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

   3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

   3.2.1 Service Life: 10,000 hours min.

   3.3 Design

   3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

   3.4 Detail Performance Requirements

   3.4.1 Power Requirements: 105-125 VAC, 55-420 CPS, single phase

   3.4.2 Output Voltage:

16-40V RMS	in	2 volt steps
40-100V RMS	in	5 volt steps
100-300V RMS	in	10 volt steps

   Programming Accuracy $\pm 2\%$

   3.4.3 Output Current: 7 amps max.

   3.4.4 Static Regulation: A variation in input voltage ($\pm 10\%$ of nominal) shall not cause an output voltage change of more than $\pm 1\%$. A 50% to 100% change in load shall not cause an output voltage change of more than $\pm 2\%$.

3.4.5 Speed of Response: Power supply shall be capable of covering 20% of the programmed range voltage within 1 sec.

3.4.6 Response to Simultaneous Line and Load Variations: The output voltage shall not change more than $\pm 2\%$ for any combination of line voltage change ($\pm 10\%$ of nominal) and load change of $\pm 10\%$ over the input frequency range.

3.4.7 Output Impedance: Less than .5 ohms.

3.4.8 Metering: A meter shall be provided to cover the output voltage in two ranges (0-50V, 0-500V). The meter ranges shall be automatically selected depending on the voltage programmed. The accuracy of the meter shall be $\pm 2\%$ of full scale.

3.4.9 Short Circuit Protection: Provision to protect the power supply against short circuit shall be provided.

3.4.10 Programming: All programming will be done by applying externally supplied D. C. levels to the power supply control lines.

3.4.10.1 Control Lines: The output voltage shall be programmed by means of ten control lines weighted as follows:

1. 1
2. 2
3. 4
4. 8
5. 10
6. 20
7. 40
8. 80
9. 100
10. 200

Ranging information and selection, if necessary, shall be obtained from these BCD inputs and appropriate logic circuitry internal to the supply.

3.4.10.2 Programming Time: The maximum time required to change from a given range and voltage to a new range and voltage shall not exceed 50 milliseconds.

3.4.10.3 Transient Behavior During Programming: When programming a higher voltage than the previously programmed level, the output voltage waveform shall be continuous and the transient voltage output during programming shall not be less than the previous level or exceed the newly

programmed level by more than 3%. When programming a voltage less than the previously programmed level, the output voltage waveform shall be continuous and the transient voltage output during programming shall not exceed the previous level nor fall below the newly programmed level by more than 3%.

3.4.11 Warmup Time: The time required after application of primary power for the output voltage to be programmable with the accuracy specified in paragraph 3.4.2 shall not exceed 45 seconds.

Appendix 40

Purchase Description

Programmable A.C. Power Supply (6.3V)

1. Scope

1.1 Scope: This specification covers the general and detail requirements for an A.C. power supply in the 6.3V range.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 Power Requirements: 105-125V AC, 55-420 cps, single phase

3.4.2 Output Voltage: 6.3V AC ±2%

3.4.3 Output Current: 10 amps maximum.

3.4.4 Static Regulation: A variation in input voltage (±10% of nominal) shall not cause an output voltage change of more than ±.5%.

A no load to full load or full load to no load step change shall not cause an output voltage change of more than ±2%.

3.4.5 Speed of Response: .55 volts/sec

3.4.6 Output Frequency: 400 cps ± 5%.

3.4.7 Response to Simultaneous Line and Load Variations: The output voltage shall not change more than ±2% for any combination of line voltage change (±10% of nominal) and load changes of ±10%.

3.4.8 Output Impedance: Less than .01 ohm.

3.4.9 Short Circuit Protection: Provision shall be made to protect the power supply against short circuit.

3.4.10 Warmup Time: The time required after application of primary power for the output voltage to be within the accuracy specified in Paragraph 3.4.2 shall not exceed 45 sec.

Appendix 41
Purchase Description

Programmable 30 cps Supply

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable 30 cps power supply.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational, and life requirements designated herein.

3.2.1 Service Life: 10,000 hrs. min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 General

3.4.1.1 Programming: All programming will be done by applying externally supplied DC levels to the 30 cps power supply.

a. Type of function programmed - The 30 cps power supply shall be programmable to furnish either a reference 30 cps and + or - 90° phase shifted outputs (resolver input simulation) or a reference 30 cps and 2 180° phase shifted outputs (synchro simulation).

b. Output Voltage Programming - Output voltage of the ± 90° phase shifted outputs shall be programmable in the range of 2.2 volts to 10.2 volts in 1 volt steps. Output voltage of the 2 180° phase shifted outputs shall be programmable in the range of 0 volts to 20 volts in 1 volt steps.

c. Programming Time - The maximum time required to change from a given type output to a new type output shall not exceed 25 milliseconds.

d. Program Memory - Function control relays shall not utilize latch up circuits requiring external unlatch commands. A programmed function shall remain set up only while the appropriate control lines are held at the most positive programming voltage level with respect to common. When a control line drops to the most negative programming voltage, it's corresponding relay, or relays will return to the de-energized state.

3.4.1.2 30 cps Source: The 30 cps power supply shall be capable of generating its own internal 30 cps signal source or using an external 30 cps source.

3.4.1.2.1 Frequency Accuracy: The 30 cps internal signal source frequency accuracy shall be ± 1%.

3.4.1.2.2 Distortion: Distortion in either reference output or phase shifted outputs shall be less than 5%.

3.4.2 Reference and ± 90° Phase Shifted Outputs: In this mode of operation, a reference 30 cps and a phase shifted output at + 90° or - 90° with respect to the reference shall be available.

3.4.2.1 Output Voltage: Output voltage of reference shall equal output voltage of phase shifted component. These outputs shall be simultaneously programmable over the range of 2.2V - 10.2 volts in 1 V steps. Output voltage accuracy ± 2%.

3.4.2.2 Output Current: The power supply shall be capable of furnishing 20 ma from the reference and each phase shifted output.

3.4.3 Reference and 180° Phase Shifted Outputs: In this mode of operation the power supply shall be capable of furnishing a REF and two isolated 180° phase shifted outputs.

3.4.3.1 Output Voltage: Output voltage of REF and 180° phase shifted outputs shall be independently programmable over the range of 0V to 20V in 1V steps, output voltage accuracy ± 2%.

3.4.3.2 Output Current: The power supply shall be capable of furnishing 20 ma from each output.

Appendix 42

Purchase Description

Programmable A.C. Power Supply 95-130V.

1. Scope

1.1 Scope: This specification covers the general and detail requirements for a programmable A.C. power supply in the 95-130V range.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 Power Requirements: 105-125V AC, 55-420 cps, three phase.

3.4.2 Output voltage: 95 - 130 volts AC in 1 volt steps, programming accuracy ±1 volt. Output frequency 380 - 420 cps.

3.4.3 Output Current: 40 amps max.

3.4.4 Static Regulation: A variation in input voltage (±10% of nominal) shall not cause an output voltage change of more than ±0.5% from 95-130 volts output. A no load to full load or full load to no load step change shall not cause an output voltage change of more than ±2%.

3.4.5 Speed of Response: 20 volts/sec.

3.4.6 Response to Simultaneous Line and Load Variations: The output voltage shall not change more than $\pm 1\%$ for any combination of line voltage changes ($\pm 10\%$ about nominal) and load changes of $\pm 10\%$ over the input frequency range.

3.4.7 Output Impedance: Less than .05 ohms.

3.4.8 Metering: A meter shall be provided to cover the output voltage range. The accuracy of the meter shall be $\pm 1\%$ of full scale.

3.4.9 Short Circuit Protection: Provision to protect the power supply against short circuit shall be provided.

3.4.10 Programming: All programming will be done by applying externally supplied D.C. levels to the power supply control lines,

3.4.10.1 Control Lines: The output voltage shall be programmed by means of nine control lines weighted as follows:

1.	1
2.	2
3.	.
4.	8
5.	10
6.	20
7.	40
8.	80
9.	100

3.4.10.2 Programming Time: The maximum allowable time for switching from one voltage level to another shall not exceed 25 millisec.

3.4.10.3 Transient Behavior During Programming: When programming a higher voltage than the previously programmed level, the output voltage waveform shall be continuous and the transient voltage output during programming shall not be less than the previous level or exceed the newly programmed level by more than 1%. When programming a voltage less than the previously programmed level, the output voltage waveform shall be continuous, and the transient voltage output during programming shall not exceed the previous level nor fall below the newly programmed level by more than 1%.

3.4.11 Warmup Time: The time required after application of primary power for the output voltage to be programmable with the accuracy specified in paragraph 3.4.2 shall not exceed 45 seconds.

Appendix 43

Purchase Description

Programmable A.C. Power Supply

1. Scope

1.1 Scope: This specification covers the general and detail requirements of an A.C. power supply (104-130 volts, three phase)

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detail Performance Requirements

3.4.1 Power Requirement: 105-125V AC per phase, 55-420 cps, three phase, wye connected.

3.4.2 Output Voltage: 104-130 volts AC per phase in 2 volt steps, 380-420 cps

Programming Accuracy ± 1 volt.

3.4.3 Output Current: 15 amps max. per phase.

3.4.4 Static Regulation: A variation in input voltage ($\pm 10\%$ of nominal) shall not cause an output voltage change of more than $\pm .5\%$.

A no load to full load or full load to no load step shall not cause an output voltage change of more than $\pm 1\%$.

3.4.5 Speed of Response: 20 volts/sec.

3.4.6 Response to Simultaneous Line and Load Variations: The output voltage shall not change more than ±1% for any combination of line voltage variation (±10% of nominal) and load change (±10%).

3.4.7 Output Impedance: Less than .05 ohms.

3.4.8 Metering: A meter shall be provided to cover the output voltage range. The accuracy of the meter shall be ±1% of full scale.

3.4.9 Short Circuit Protection: Provision to protect the power supply against short circuit shall be provided.

3.4.10 Programming: All programming will be done by applying externally supplied D. C. levels to the power supply control lines.

3.4.10.1 Control Lines: The output voltage shall be programmed by means of eight control lines weighted as follows:

1.	2
2.	4
3.	8
4.	10
5.	20
6.	40
7.	80
8.	100

3.4.10.2 Programming Time: The maximum allowable time for switching from one voltage level to another shall not exceed 25 millisec.

3.4.10.3 Transient Behavior During Programming: When programming a higher voltage than the previously programmed level, the output voltage waveform shall be continuous and the transient voltage output during programming shall not be less than the previous level or exceed the newly programmed level by more than 1%. When programming a voltage less than the previously programmed level, the output voltage waveform shall be continuous, and the transient voltage output during programming shall not exceed the previous level nor fall below the newly programmed level by more than 1%.

3.4.11 Warmup Time: The time required after application of primary power for the output voltage to be programmable with the accuracy specified in paragraph 3.4.2 shall not exceed 45 seconds.

Appendix 44

Purchase Description

Programmable Transfer Oscillator 12-18 KMC

1. Scope

1.1 This Purchase Description covers the detailed requirements for a programmable transfer oscillator and mixer for frequency measurements in the range of 12-18 KMC.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general purchase description No. MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detailed Performance Requirements

3.4.1 General

3.4.1.1 Power Requirements: 105 - 125 V AC 55 - 420 cps single phase.

3.4.1.2 Sensitivity: .1 V RMS

3.4.1.3 Frequency Range: 12 - 18 KMC

3.4.1.4 Resolution: 100 MC

3.4.1.5 Accuracy: .0005%

3.4.1.6 Power Output: 50 milliwatts

3.4.1.7 Programming: All programming will be done by applying externally supplied DC levels to the transfer oscillator control lines.

3.4.1.7.1 Functions Programmed

3.4.1.7.1.1 Frequency in 100 MC steps from 12 to 18 KMC

3.4.1.7.2 Programming Time: Maximum time to change from one frequency to another shall be 25 milliseconds.

PURCHASE DESCRIPTION

Programmable Function Generator

1. Scope

1.1 This purchase description covers the detailed requirements for a programmable function generator capable of generating sawtooth, triangular and trapezoidal wave shapes from a square wave or pulse input.

2. Applicable Documents (MDNE-PD-63)

3. Requirements

3.1 General Purchase Description: The requirements of general Purchase description MDNE-PD-63 apply as requirements of this purchase description. When the two purchase descriptions conflict, this purchase description shall govern.

3.2 The unit shall perform its designated function successfully within the operational and life requirements designated herein.

3.2.1 Service Life: 10,000 hours min.

3.3 Design

3.3.1 Controls: An auxiliary on-off switch shall be provided in an accessible location. All other functions are to be performed from a remote source.

3.4 Detailed Performance Requirements

3.4.1 General

3.4.1.1 Power requirements 105-125 V AC - 50 to 420 cycles single phase.

3.4.1.2 Frequency range 100 to 2500 pps depending on frequency of driving pulse.

3.4.1.3 Output - Programmable 0 - 50 V peak in 5 volt steps $\pm$ 5% of programmed value, Triangular, Trapezoidal or sawtooth waves.

3.4.1.4 Retrace time of sawtooth shall be less than 5% of trace at all frequencies.

3.4.1.5 Non Linearity of trace and of triangular wave shall be less than 1%.

3.4.1.6 Rise time of trapezoid shall be variable by preset manual adjustment between .5 to 5 milliseconds, non programmable.

3.4.1.7 Programming - All programming will be done by applying externally supplied DC levels to control lines.

3.4.1.7.1 Type of wave, triangular, sawtooth or trapezoidal shall be programmable.

3.4.1.7.2 Output shall be programmable for 0 to 50 volts peak ± 5% of programmed value, in 5 volt steps.

3.4.1.7.3 Programming time to go from one type of wave to another or one output to another shall not exceed 25 milliseconds.

Appendix 46

PROGRAMMER-CONTROLLER SPECIFICATION

1. General Functional Requirements

The basic functions of the Programmer-Controller shall be to detect and interpret information contained on a coded perforated tape and on the basis of this information to:

a. Produce outputs capable of selecting and programming stimulus generators, switching units, response monitors and programmable accessories.

b. Compare a measured value from a response monitor with preset limits for that measurement.

c. Record the measured parameter and test evaluation, store the test result and select the next test as required by the evaluation.

d. Signal and transmit test information and tape instructions to a Control Computer, direct the test system a s commanded by the Control Computer.

1.1 Program Control - The Programmer-Controller shall be capable of operating automatically from instructions on the tape, semi-automatically with instructions from the tape and under control of the operator, manually with instructions from the operator or under direction of the Control Computer.

1.2 Fail Safe - Provision shall be made for test system shut down without damage to the system or equipment under test in the event of a malfunction in the system.

1.3 Reliability and Self Test - Reliability shall be a prime design objective to obtain a maximum trouble free operating period. Solid state devices shall be used wherever practical. Provision shall be made for self tests that will verify proper operation of all functions.

1.4 Fault Isolation and Maintainability - Fault isolation devices shall be provided in the Programmer-Controller to facilitate quick isolation of a malfunction. To insure optimum maintainability and supportability, the construction shall be of a modular type with division by function (i.e., tape reader with drive and read circuitry, comparator with limit registers and gating, printer with storage registers, decoders and drivers). All appropriate fault isolation devices and indicators should be physically located on the module or building block with which they are associated.

2. Tape Reader

The tape reader shall be a motor-driven bi-directional, eight level, photoelectric sensing type capable of sensing coded perforated intelligence on the program tape and converting this intelligence into electrical signals that can be decoded by a binary decoding sytem. The tape reader shall be capable of performing these conversions at a rate of at least 150 frames per second, slew (rewind) at a rate of at least 800 frames per second and so designed that it can be stopped on the frame that emits the tape stop command, except during rewind.

2.1 General Operation - Once actuated by its manual start switches, the tape reader shall process the tape under automatic or semi-automatic (manually controlled one test at a time) control, dependent upon the mode of operation selected by the operator. Semi-automatic operation shall be directed by the operator during semi-automatic mode. Automatic operation shall be as directed by the programmed tape.

Specific programmable functions that affect operation of the tape reader shall be as follows:

a. Program Stop

b. Program Hold

c. Program End

2.1.1 Program Stop - A program stop shall be a tape stop that requires manual actuation of the reset program stop switch and/or operation of the start controls.

2.1.2 Automatic Stop - An automatic program stop shall occur when even parity is detected or an error or fail safe condition is detected in the unit or detected in building blocks associated with the unit. An automatic stop shall be fail safe to the extent that any encoded or simulated tape command generated after the occurrence of an automatic stop shall be inhibited and all test point and stimulus switching be opened or set to "0" state. Restoration of command capability shall require operation of the stop control and subsequent operation of the start controls.

2.1.3 Selected Program Stop - A selected program stop shall occur when programmed on the tape. Programmable signal sources that shall cause a selected program stop are:

a. A no-go signal from the comparator or events sequence detector.
b. A signal from system timing units denoting end of pre-set time delays. (Delay generator)
c. A signal from a weapon system monitoring device.

2.1.4 Hold Program - A hold program shall be any temporary stop of the tape that can be restored by a programmed signal. The programming set shall be capable of restart upon receipt of a signal from any one of the following signal sources.

a. End of a pre-set time limit.
b. Go from comparator.
c. High from comparator.
d. Low from comparator.

e. No-go from comparator or events sequence detector.

f. Signal from system under test.

2.1.5 End Program - An end program shall occur at the end of any series of test sequences. This shall be a tape-commanded signal that will stop the tape reader and actuate a visual display on the monitor panel.

2.2 Tape Sensing Requirement - The tape reader shall be capable of processing an eight-level, aluminum mylar, laminated type tape of 1 inch width, with information density of 10 rows per inch. It shall be capable of sensing address and information data from a prepared tape that has been encoded in accordance with the following criteria:

2.2.1

Levels	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7
1	Parity	Parity	Parity	Parity	Parity	Parity	Parity
2-3-4	"Identity						
5-6-7-8	Address"	"Sub-Identity Address"	Digit	Digit	Digit	Digit	Digit

The sub-identity address occurs only when necessary. A "0" in levels 2-3-4 of row 2 indicates there is no sub-identity causing the row counter to advance from row 1 to 3. This allows a digit that is physically in row 2 to be treated as row 3 information.

A "1" in levels 2-3-4 of rows 3-7 shall indicate the end of a data block, allowing variable length blocks. Presence of a "2" in levels 2-3-4 of last row indicates the block concerns a test number, and causes a reverse shift in reading the block during backward search.

"3", "4", "5", "6" and "7" in levels 2-3-4 of row 2 through 7 shall be used for peculiar control functions such as reverse control for the Control Computer, etc.

2.2.2 Tape Coding - Tape levels in each tape frame shall be assigned binary coded values to represent the addresses, instructions, and numbers necessary to operate the Programmer-Controller.

2.2.3 Utilization - The decoded addresses shall provide information to direct the associated instructions internal to the Programmer-Controller and for external use by the associated stimulus and response equipment.

2.3 Tape Reader Controls - The following controls shall be provided on the Control Panel:

a. Switch to select automatic, semi-automatic, or manual modes.

b. Switch to start the tape reader when in automatic mode of operation.

c. Switch to advance the tape one test at a time when in semi-automatic mode of operation.

2.3.1 Test Search Switch - The test search switch shall initiate the test search mode of operation.

2.3.2 Manual Entry - The tape simulator control shall consist of the switches necessary to simulate information encoded on a tape. This control shall also provide the means for designation of the test number and end item identities to be selected by the test search switch.

2.3.3 Equipment Status Indicators - The following indicators shall depict the equipment status:

a. Lights to indicate holes in tape being sensed.

b. Lights to show even parity, odd parity.

2.3.4 Continuous Conversion Control - A switch shall be provided to allow continuous measurement, comparison and display to occur.

2.3.5 Parity Check - The parity checking circuit shall be capable of verifying that an even number of holes are being sensed by the tape reader. Failure of this check to verify proper parity shall automatically cause a program stop and a visual indication of the failure.

2.4 End Item Identity Information Storage - The end item identity storage element shall store the end item identity information that is decoded from the tape. It shall provide this information as reference for the search operation and for transmission to the Control Computer.

2.5 Visual Display Unit - The visual display unit shall consist of lights and numerical readout devices to automatically provide display of the following:

a. Numerical - visual indicators shall display in numerical form:

1. Test number 4 digits
2. Measured value 7 digits
3. Multipliers
4. Decimal point
5. Type of measurement
6. Type of test

b. Lights - lights shall indicate:

1. Test results - High, Low, "Go", "No-Go"
2. Test in progress
3. End of test
4. Standby
5. External hold
6. Internal hold

7. Fail safe

8. Warm up

9. Operating Mode - Automatic, Semi-Automatic, Manual, Monitor, Search

10. Operational test bench indicator

11. Address and Program line levels

12. Building Block Program error

13. Control Computer Direction

Provision shall be made for simultaneous operation of more than one identical display.

2.6 Measurement Comparator - The comparator shall be of the semi-conductor type consisting of two digital comparator circuits, the upper limit storage circuit, the lower limit storage circuit, and the necessary interconnecting logic circuitry to accomplish evaluation of the measured value as may be programmed. The comparator shall be capable of storing the required results of the first of two serial comparisons and combining them with the results of a second comparison to effect an overall eight-digit comparison.

2.6.1 Comparison Function - The comparator shall compare measured digital values received from response monitors with upper and lower limits simultaneously. This comparison shall be on a parallel basis. A measured value equal to limit shall be accepted as a "Go".

The comparator shall provide "Go", "No-Go", high and low signal outputs as required to reflect results of each comparison process or the results of two related serial comparisons when so programmed.

2.6.2 Comparator Reset - The output of the measurement comparator shall be turned off by manual reset or tape reset command.

2.7 Printer - The printer mechanism shall be a parallel entry, 21 column device capable of printing the following information on one print cycle.

Measurement value and Dec. point	5 column
Test Number	4 column
Upper Limit	4 column
Lower Limit	4 column
Test Results	1 column
Multiplier	1 column
Function	1 column
Limits Polarity	1 column

The printer mechanism and the printout controller shall be capable of six print cycles per second.

2.8 Printer Controller - The printer controller shall include the circuitry necessary to decode information from the overall sytem for use by the printer. Design shall be such that complete or partial printout shall be made on the basis of tape instructions. Provision shall be made for the serial printout of measured values, limits and test results on a measurement involving more than four digits.

2.9 Control Panel - The control panel shall contain all necessary switches and controls to command normal operation of the Programmer-Controller.

Power controls shall consist of the following:

a. Programmer-Controller on-off switch

b. Accessory (Building Blocks) on-off switch

c. Master on-off switch

The following controls shall be provided for the operation of the test system.

a. Switches to select automatic, semi-automatic, manual, search and monitor modes of operation.

b. Switches to select a test number for search.

c. Switches to select an end item identity for search.

d. Program start-stop switch.

e. Controls suitable for manually entering test information into the Programmer-Controller.

f. Test repeat switch.

g. Fail safe stop switch.

h. Bench override switches.

i. Operational override switch.

The Programmer-Controller shall be so designed that multiple control panels may be remotely positioned and operated.

2.10 Search - The Programmer-Controller shall be capable of searching the tape to a particular end item identity number (Federal Stock, Class number) or to a particular test number. Selection of the test number may be inserted from the program tape or manually by the manual entry control. End item identity will be selected by the manual entry control.

It shall be possible to automatically revert to normal operation at the end of search. All information except test numbers or end item identity numbers shall be inhibited during the search operation.

When the test number search operation is selected by the program tape, it shall be possible to actuate the search by any of the following signal sources.

a. End of programmed time delay.

b. Signal from events sequence detector.

c. "Go", "No-Go", "High" or "Low" from comparator.

d. Signal from tape.

e. Manually operated switch.

f. Signal from system under test.

2.11 Iteration - The Programmer-Controller logic shall be so designed that on instruction from tape information blocks it will revert to an iteration process. This process will be used where many consecutive tests are of the same type (continuity, resistance) with all test information the same except test number and test point switching or for series of tests where only a few other instructions change (stimulus generator frequency change for frequency response tests, marginal voltage tests, etc.).

Tape blocks shall instruct what functions are to be changed for the iteration process, how many times the process shall be changed and on what test the process is to start.

The test number register and program registers in building blocks shall be designed such that after receipt of an iteration command, the next address will cause a selected step in function until a program release occurs.

After reading through the iteration instructions, the Programmer-Controller will repeat a test or a selected consecutive group of tests for the required number of times, changing the selected functions (test number, voltage, frequency, etc.) by a given step and proceed to the next test automatically. All normal control functions of the Programmer-Controller shall apply during the iteration process.

2.12 Events Sequence Detector - The events sequence detector shall be capable of detecting the sequence of two events and generating a "go" or "no-go" signal depending on the program. The events to be detected may be the end of a programmed time delay from an associated delay generator and a signal from the sytem under test.

2.13 Test Result Memory - The test result memory shall accept, store and present in parallel form the results of thirty-four (34) tests. The input shall be programmable to accept the following outputs from the comparator.

a. High

b. Low

c. Go

Outputs shall be made available to the comparator input switching, 17 bits at a time on lines corresponding to the external digital inputs to the comparator. . Reset shall be accomplished by tape information.

2.14 Control Computer Input Logic - Eight digital input lines shall be provided to give the Control Computer access to the test system. These lines shall be gated in parallel to the tape reader outputs. The signal to disconnect the tape reader outputs and connect the computer shall be received from the computer.

Control Computer Output Logic - The Programmer-Controller shall provide an output of 10 sense lines for the Control Computer. Information on these lines shall be fixed by the sense line controls.

An 8-line digital information output shall transmit information (tape output, measured value, test results, test number, end item identity) from the Programmer-Controller to the Control Computer. Transmission of data shall be controlled by a control line from the Control Computer.

A reverse control line capable of addressing the Control Computer from tape information or manual means shall be supplied by the Programmer-Controller.

2.15 **Program Memory Unit** - The addressing and programming methods desired require internal storage of all building block programming information. In the interest of reducing problems in mating programming lines to program input and storage, a standardized program memory is desirable. By standardizing mounting, circuitry and components the cost of design, building and supporting is cut to a minimum. Although all building blocks do not require the same programming information from the input lines, the information and, therefore, the program memory will differ in quantity only. The program memory units will contain only the required capacity but will have interchangeable sub-units (printed circuit cards).

2.15.1 Input voltage shall be obtained from the Decoder Unit

2.15.2 Program inputs - The memory unit shall accept logical voltage levels on twenty lines. Upon receipt of an enable logical level from a decoder and the programming information, the program shall be read into the memory. The memory shall hold until power shutdown, reprogramming, or reset.

2.15.3 Noise rejection - The memory unit will accept an enable level only when the enable level is present for a time longer than the duration of normal contact bounce.

2.15.4 Outputs - The memory unit shall provide adequate logic level outputs to program the building block with which it is associated.

2.15.5 Fail Safe - A fail safe device shall be provided which will produce a logical level output when any of the twenty programming lines internal to the memory unit are grounded or open circuited.

2.16 Universal Decoder Unit - The universal decoder unit is intended as a plug-in unit for all building blocks. Its function is to detect an adress on an eleven line address buss intended for the building block where it is located. The coincidence of the address code and the internal preset code will allow the program information to be fed into the addressed building block. The use of switches to set up the preset code allows all decoders to be identical and interchangeable.

2.16.1 Input Voltage 105-125 VAC

2.16.2 Input Frequency 55-420 cps

2.16.3 Address Input - The decoder shall accept logical voltage levels on an eleven line address buss. The eleven lines shall be divided into two functions, 7 lines for a building block type identity address and 4 lines for a building block sub-type identity address.

2.16.4 Preset Codes - Switches shall be provided such that any of the 128 (possibly 79) code combinations on the 7 type building block type identity lines can be preset in the decoder unit.

2.16.5 Switches (covered but readily accessible from front) shall be made available to set up two preset codes for the four line building block sub-type address. Provisions shall be made for the selection of any one of these preset codes upon receipt of a signal on one of two lines corresponding to the two groups of switches.

2.16.6 Decoder Output - The decoder shall provide a logical level output upon receipt of a code on the 7 line address and four line address which coincides with the preset codes.

2.16.7 Fail Safe Output - A fail safe device shall be provided which will produce a logical level output when any of the eleven lines internal to the decoder are grounded or open circuited.

2.16.8 D.C. Power Output - D.C. voltage adequate for the standard memory unit shall be provided.

2.17 Coax Switching Unit

2.17.1 Input Voltage 105-125 VAC

2.17.2 Input Frequency 55-420 cps

2.17.3 Programming Input - The coax switching unit must accept the universal decoder unit and contain the programming memory unit controlled by 20 programming lines.

2.17.4 Switching - Each switch shall have capabilities of switching any of five inputs to any of five outputs. If rotary driving devices are employed position feedback must be used such that the drive device is de-energized by a control signal associated with the selected position.

Number of Switches per unit - 4, 5, or 6

Insertion Loss - Less than 0.3 db input to output

Isolation - Better than 30 db at 1 Kmc

Connectors - Input-One connector for each input line
(located on back panel)
Output-One connector for each output line
(located on front panel)

2.17.5 Indicators - A position indicator shall be provided such that the position of each switch may be visually detected from the front panel.

2.18 Low Frequency Stimulus Switching Unit

2.18.1 Input Voltage 105-125 VAC

2.18.2 Input Frequency 55-420 cps

2.18.3 Program Inputs - The low frequency stimulus switching unit shall accept the universal decoder unit and shall contain the standard program memory unit. Control of the switching unit shall be accomplished by the programming buss line.

2 18.4 Switching Capability - The switching shall be divided into three identical groups. Each group shall have seven inputs and seven outputs arranged such that any of the inputs can be connected to any of the outputs. Each switching group shall operate independently such that an input-output connection in each of the three groups may be made simultaneously.

Connectors - Input - One connector for each input line (located on back panel)

Output - One seven pin connector for each switching group (located on front panel)

2.19 Low Frequency Response Monitor Switching Unit

2.19.1 Input Voltage 105-125 VAC

2.19.2 Input Frequency 55-420 cps

2.19.3 Program Inputs-The low frequency response monitor switching unit shall accept the universal decoder unit and shall contain the program memory unit. Control of the switching unit shall be accomplished by the programming buss lines.

2.19.4 Switching Capacity - The switching unit shall be capable of connecting any of 99 test point inputs to any of 7 outputs to response monitors.

Connectors - Input - 2 connectors, 50 pins each (located on front panel)

Output - 7 single pin connectors (located on back panel)

2.20 Waveguide Switching Unit

2.20.1 Input Voltage 105-125 VAC

2.20.2 Input Frequency 55-420 cps

2.20.3 Program Inputs - The waveguide switching unit shall accept the universal decoder unit and contain the program memory unit. Control of the unit will be accomplished by the programming buss lines.

2.20.4 Switching Capabilities - Each waveguide switch shall be capable of switching one input to either of two outputs.

Switches per unit - 3

Insertion Loss - less than .2 db

Isolation - better than 30 db

2.20.5 Frequency - units will be designed for L, S, X and Ku frequency bands.

APPENDIX 47

ATE Repair Costs

Sub-assemblies:

No. of Units	-	6,240 per year	1 1/2 modules/per unit
Equipment Costs	-	\$ 690,868	
Equipment Development	-	\$ 960,751	

Man hours for Module Isolation per Year: 18,366 man hours

Direct Labor @ 323/hr.	\$ 59,323	
100% Overhead	59,323	
Depreciation	165,162	
Sub-total Costs		\$ 283,808

Module Repair Costs:

780 $\frac{\text{Modules}}{\text{month}}$ x 12 months x \$19.187/module 179,590

Total yearly costs \$463,398

Maint. Costs/Subassembly $\frac{\$463,398}{6,240}$ = \$ 74.263

Man hours/Subassembly $\frac{18,366}{6,240}$ + (1.228 x 1.5) = 4.785 $\frac{\text{man hours}}{\text{subassembly}}$

Replacement of parts (30 min) = $\frac{.5}{4.785}$ . .1045

$\frac{\text{Maint. Costs}}{\text{Subassembly}}$ - parts replacement = \$74.263 (1 - .1045) = \$66.503

Average Real Hours per Subassembly = $\frac{365.25 \times 24}{6,240 \text{ units}}$. 1.40 hours

Modules (780 modules for subassembly, 496 modules for repair per month)

Number of Modules per year	15,312 units
Equipment Cost	\$720,832
Equipment Development	\$ 1,002,500

Manhours for module repair per yr. 18,803 man hours

Costs:

Direct Labor @ 3.23/hr.	$ 60,732	
100% Overhead	60,732	
Depreciation	172,333	
Sub-total Costs		$293,797

Maintenance Cost/Module $= \dfrac{\$293,797}{15,312 \text{ units}} = \$19.187$/module

Man hours/Module $= \dfrac{18,803}{15,312} =$ 1.228 man hours/module

Module Cost per Year:

$496 \times 12 \times \$19.187 = \$114,201$

$5952 \dfrac{\text{modules}}{\text{yr.}} \times 19.187$

Replacement of parts (20 min) $= \dfrac{.3333}{1.228} = 0.2714$

$\dfrac{\text{Maint. Costs}}{\text{Module}}$ - parts replacement $= 19.187\,(1-0.2714) = \$13.980$/module

Average Real Hours per Module $= \dfrac{365.25 \times 24}{496 \times 12} = 1.473$ hours/module

APPENDIX 48

Manual Repair Costs

Major Assembly

		Yearly Workload	Man Hours
RT-274C/APN-81	- Radar R.T.	72	1740
AM-742A/APN-81	- Elec. Control Amp.	36	648
AM-758B/APN-81	- Elec. Control Amp.	100	2596
CU-469A/ARR-39	- Indicator Coupler	20	500
CU-469B/ARR-39	- Indicator Coupler	32	800
CV-553/ARR-39	- Sig. Data Conv.	40	1332
RT-220B/ARN-21	- R.T.	1304	16,180
T-608/ALT-6B	- R.T.	99	594
PP-1533/AlT-6B	- Pwr. Supply	476	1808
5281-646-5103	- Radio Set 618S-1A	108	1542
5821-509-8742	- Radio Set 618S-1	100	1428
5821-333-8518	- Ant. Tuner	120	570
RT-263/ARC-34	- R.T.	1108	13,500
RT-463/ARC-34	- R.T.	124	1,500
IP-239/APN-59		352	8,700
RT-289A/APN-59	- R.T.	392	6,532
AM-853/APN-59	- Elec. Control Amp.	92	1,108
PP-1073/APN-59	- Power Supply	188	1,612
IP-268/APN-59	- Indicator	320	3,720
PP-1260/APN-59	- Power Supply	60	286
RT-400/ARC-65	- R.T.	245	7,420

	Yearly Workload	Man Hours
T-605/ARC-58 - Trans.	60	902
R-761/ARC-58 - Rec.	104	3,150
CU-5231/ARC-58 - Ant. Coupler	88	440
C-1940/ARC-58 - Ant. Coupler Control	80	480
RT-156/APS-42 - Radar Trans.	96	1,156
SN-59/APS-42 - Synchronizer	76	1,420
RT-275/APS-42A - R.T.	284	2,420
SN-59A/APS-42A - Synchronizer	160	2,000
	6335	86,084
Modules		
PS-6113-38/APN-81 - Pwr. Supply	120	960
C-1416A/APN-81 - Control	16	62
AS618C/APN-81 - Antenna	120	2,400
C-1160/APN-81 - Control, Vertical Gyro	96	430
AM-743/APN-81 - Electrical Control Amp.	56	230
PS-6013-40/APN-81 - Pwr Supply	24	120
CP-185V/APN-81 - Computer Freq. Tracker	20	680
C-1672/ARR-39 - Rec. Control	12	48
7732198G-1 - Clr one & Clr two	20	666
7731628G-1 - Tunning Control	16	32
7630370G-1 - Control Monitor	20	80
7730949G-2 - Altitude Speed & Range	40	160
76313686-1 - Binary Counter	20	80
7630561G-2 - Angle Subtractor	60	240

Total Black Box

6,336

Total Man hrs.

86,084

APPENDIX 48 (CONTD)

		Yearly Workload	Man Hours
R-539B/ARN-14B	- Rec.	224	3,340
C-760A/ARN-14B	- Control Panel	168	440
C-996A/ARN-14B	- Control Panel	236	620
C-1763/ARN-21	- Control	236	480
C-1970/ALT-6B	- Mag. Freq. Control	65	1,260
C-1965/ALT-6B	- Control Ind.	283	5,500
----	Oscillators	743	2,972
C-1057/ARC-34	- Control	308	624
C-1047/ARC-34	- Control	184	272
MX-1489/ARC-34	- Selector Control	432	1,840
C-1256/ARC-34	- Control Monitor	360	754
AM-868/ARC-34	- Amp. Osc.	724	3,060
R-568/ARC-34	- Rec. Subassembly	152	456
C-45/ARC-21	- Control	280	948
MX-1425/ARC-21	- Selector Control	160	640
C-1242/APN-59	- RadarSet Control	92	368
MX-1519/APN-59	- Sweep Gen.	60	132
MX-1518/APN-59	- Sweep Amp.	76	114
MX-1517/APN-59	- Sweep Relay	60	78
MX-1521/APN-59	- Range Mark Gen.	76	242
RE-315/ARC-65	- Relay Assembly	132	528
MD-296/ARC-65	- Modulator Osc.	50	300
AM-1632/ARC-65	- Amp. Det.	62	372
RE-315/ARC-65	- Relay Assembly	184	736

	Yearly Workload	Man Hours
MX-1425B/ARN-21 - Selector Control	96	384
O-495/ARC-65 - R.F. Osc.	81	324
RE-313/ARC-65 - Relay Assembly	208	832
C-451A/ARC-65 - Radio Set Control	284	1,052
PP-1806/ARC-65 - Power Supply	24	84
AM-1631/ARC-65 - Amp. Osc.	192	1,152
CV-465/URC - Mixer Oscillator	100	1,000
AM-1529/URC - Amp. Osc.	28	140
AM-1525/URC - Elec. Control Amp.	40	160
CV-531/URC - Load Phase Disc.	16	80
AM-1523/URC - Amp. Det.	28	102
AM-1527/URC - Amp. Det.	28	102
RE-284/URC - Relay Assembly	12	48
AM-1579/URC - Amp. Freq. Multi.	28	112
AM-1733/URC - Amp.	28	112
AM-1524/URC - Elec. Control Amp.	40	160
AM-1528/URC - Amp. Mixer	72	288
AM-1526/URC - Amp. Det.	28	112
AS-428/APS-42 - Antenna	64	1,184
5841-533-9659 - Power Supply	16	546
5841-505-2771 - Ind. Control	52	166
IP-39/APS-42 - Az. & Range Ind.	100	651
5841-505-2610 - Pre. Amp.	44	94

		Yearly Workload	Man Hours	
5841-504-2731	- Pwr Supply	60	204	
5841-560-6950	- AC Motor	72	936	
IP-217/APS-42A	- Az. & Range Ind.	132	860	
C-818A/APS-42A	- Radar Set Control	92	460	
AS-428A/APS-42A	- Antenna	152	2,800	
5841-538-5815	- Servo Amp.	92	331	
5841-505-2609	- IF Amp.	32	66	
5841-564-8180	- Modulator Assembly	36	216	
5841-505-2700	- A.F.C. Assembly	84	312	Total Modules
5841-036-8017	- Trig. Gen.	36	216	8,532
5841-036-8016	- Sweep Gen.	36	216	
5841-561-4250	- Range Mark Gen.	40	12	
5841-212-5917	- Servo Amp.	32	256	Total Man hours
5841-512-1237	- Range Sweep Assembly	40	80	48,114
		8532	48114	

Black Box Test Equipment

$$\$834,795 \times \frac{86,084}{134,197} = \$535,499$$

Module Test Equipment

$$\$834,795 \times \frac{48,114}{134,197} = \$299,301$$

Manual Maintenance Unit Cost

Black Box:

Labor.............86,084 MH x 3.23/hr.........	$278,051.32
100% overhead	278,051.32
Depreciation of Manual Test Equip.	53,550.00
Total	$609,652.64

Cost per Black Box = $\dfrac{\$609,652.64}{6,336 \text{ units}}$ = $96.220/Black Box

Module:

Labor...........48,114 MH x 3.23/hr.........	$155,408.22
100% overhead	155,408.22
Depreciation of Manual Test Equip.	29,930.10
Total	$340,746.54

Cost per Module = $\dfrac{\$340,746.54}{8,532 \text{ units}}$ = $39.937/module

APPENDIX 49

Maintenance Cycle Costs Per Unit

Operation	Typical Assembly RT220/ARN-21 Cost	Typical Assembly RT220/ARN-21 Time	Typical Module AM1579/ARC-58 Cost	Typical Module AM1579/ARC-58 Time
Remove from A/C	$ 1.20	0.30	$ 1.20	0.30
A&E Maint. Check	1.20	10.00	8.00	3.50
Base Clerical Support	20.00	10.00*	20.00	4.00*
Base Handling	5.00	60.00	3.00	60.00
Crating	8.50	0.75	2.00	0.60
Shipping	20.00	300.00	4.00	200.00
Depot Handling	2.00	16.00	1.50	12.00
Uncrate	1.04	.20	.70	.10
Repair (ATE)	66.50	1.40	13.98	1.47
Crating	8.50	0.75	2.00	0.60
Depot Inventory	6.00	18.00	4.00	36.00
Depot Handling	40.00	400.00	15.00	380.00
Depot Clerical Support	40.00	8.00*	40.00	8.00*
Shipping	20.00	300.00	4.00	200.00
Uncrate	1.04	.20	.70	.10
A&E Inventory	2.00	10.00	1.50	24.00
Base Clerical Support	20.00	4.00*	20.00	4.00
Base Handling	5.00	60.00	3.00	60.00
Install in A/C	2.20	0.60	2.20	.60
TOTAL	$274.98	1,[illegible]7.20 hrs.	$146.78	995.27 hrs.

* These figures represent waiting time of unit due to paper work delay

APPENDIX 50

Average Cost of Black Box

Black Box	Cost
RT128A/ARC-21	$13,980
RT263/ARC-34	3,804
OV553/ARR-39	4,000
RT178/ARC-27	1,568
R574C/ARR-39	4,000
RT400/ARC-65	16,980
CU523/ARC-58 C1940/ARC-58	2,309
R761/ARC-58	8,390
618S-1A	2,842
T605/ARC-58	4,516
RT220/ARN-21	2,450
AM758A/APN-81	2,790
AM853/APN-59	794
RT275/APS-42A	2,100
1P239/APN-59	2,073
RT289A/APN-59	4,632
1P268/APN-59	828
SN59A/APS-42	1,150
AM742A/APN-81	2,110
RT274C/APN-81	4,110
CP340/APN-105	22,832
CV448/APN-105	27,384

APPENDIX 50 (CONTD)

Black Box	Cost
CV525/APN-105	8,725
CP301/APN-105	50,000
CV447/APN-105	11,700
RT279/APX-25	725
PP1503/ALT-6B	1,462
T608/ALT-6	1,344
PP1504/APN-105	15,000
PP1073/APN-59	1,037
TOTAL	$288,269

Average Cost per Black Box $= \frac{\$288,269}{30} = \$9608.966$

APPENDIX 51

Average Cost of Modules

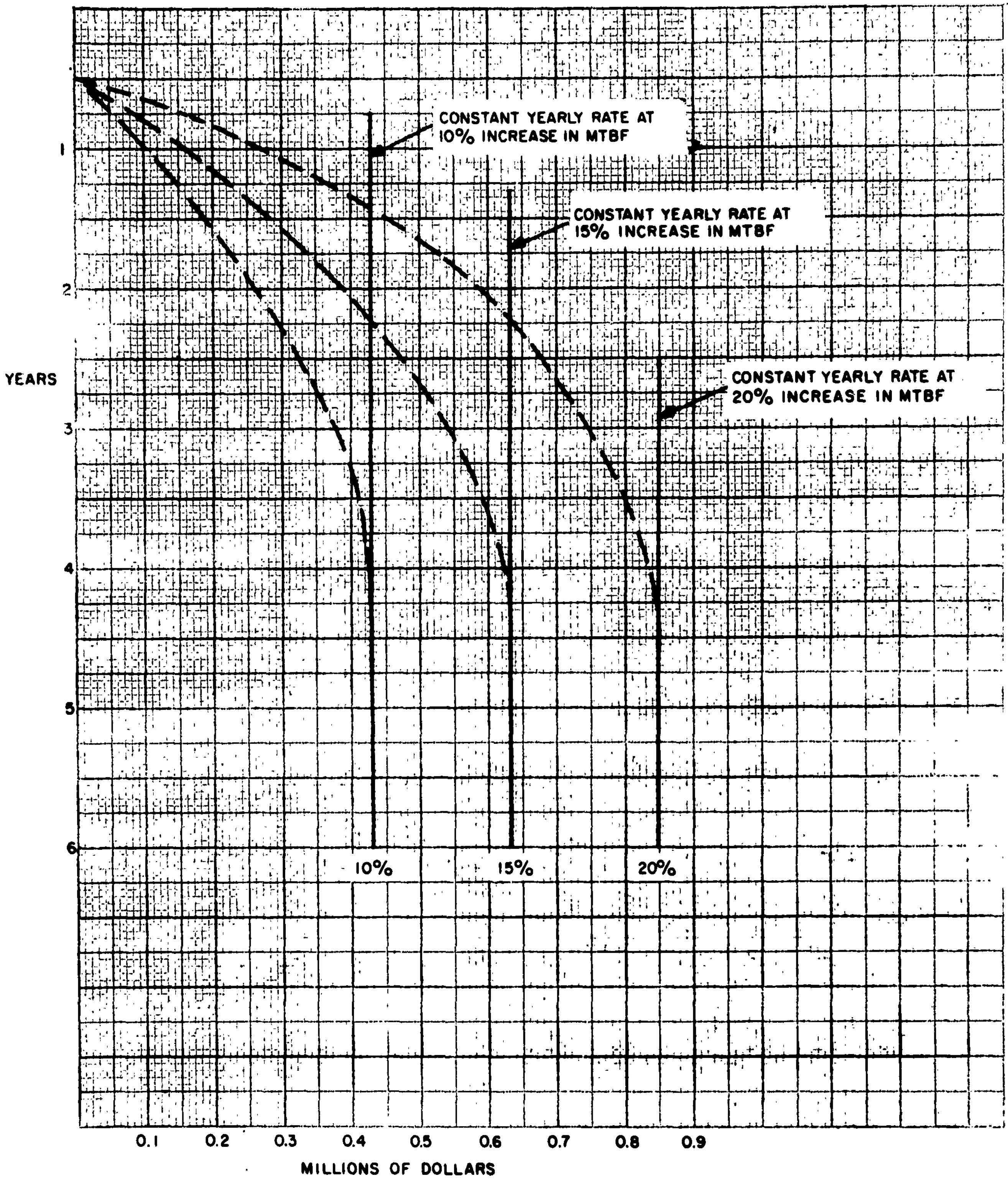
Total Cost of 30 Black Boxes..............................$288,269

Number of Modules in Black Box		
12		
4		
13		
5		
9		
5		
3		
1		
1	AS-2631/APN-59	+ 4,275.00
8		
13		
6		
1	AM743/APN-81	+ 443.00
1	CP-185/APN-81	+ 5,688.00
1	AS-618A/APN-81	+ 3,287.00
3		
27		
7		
0	Deduct CU-448/APN-105	- 27,384.00
0	Deduct CU-525/APN-105	- 8,725.00
0	Deduct CP-340/APN-105	- 22,832.00
0	Deduct PP-1504/APN-105	- 15,000.00

1	IP-215/APS-42	+ 1,219.00
5		
4		
1	AS 428B/APS-42	+ 2,130.00
2		
1	KY-95A/APX-25	+ 700.00
11		
1	3001B2/ARC-21	+ 3,277.00
11		
7		
1	C-1057/ARC-34	+ 225.00
21		
6		
0	Deduct + 605/ARC-58	- 4,516.00
12		
1	C-996A/ARN-14D	+ 90.00
1	R-541/ARN-14D	+ 1,560.00
1	DY66/ARN-14D	102.00
12		
14		
1	C-1672A/ARR-39	+ 754.00
11		
1	PP-1398/ARR-39	+ 800.00

1	PP-1236A/ARR-39	+	213.00
Total Modules	247	**TOTAL**	$234,575.00

$$\text{Cost per Module} = \frac{\$234,575}{247} = \$949.696$$



Estimation of Savings Rate for First 4 Years of AIE Shop